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Bond et al.

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(45) **Date of Patent: *Oct. 8, 2013**

(54) **COMPOSITIONS AND METHODS FOR TREATING AIDS OR CANCER BY INHIBITING THE SECRETION OF MICROPARTICLES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

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(51) **Int. Cl.**

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A61P 31/18	(2006.01)
A61K 39/00	(2006.01)
A61K 39/21	(2006.01)
C12N 5/22	(2006.01)

(52) **U.S. Cl.**

USPC **514/3.7**; 514/3.8; 424/184.1; 424/185.1; 424/188.1; 435/339.1

(58) **Field of Classification Search**

None

See application file for complete search history.

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Assistant Examiner — Jeffrey T Palenik
(74) *Attorney, Agent, or Firm* — Ping Wang; Andrews Kurth LLP

(57) **ABSTRACT**

Novel peptides that inhibit the release of microparticles from cells are disclosed. The peptide contains at least one VGFPV motif at the N-terminal and has a length of 10-100 amino acids. Also disclosed is polynucleotide encoding the peptide, expression vectors carrying the polynucleotide, and methods for treating AIDS and tumors using the novel peptides.

17 Claims, 22 Drawing Sheets

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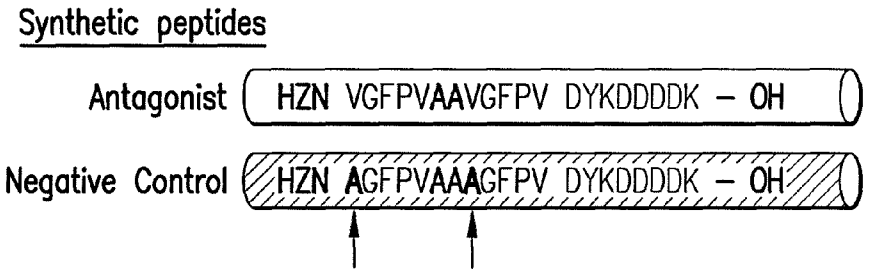
Synthetic peptides
Antagonist
HZN VGFPVAAVGFPV DYKDDDDK – OH
Negative Control
HZN AGFPVAAAGFPV DYKDDDDK – OH

FIG. 1A

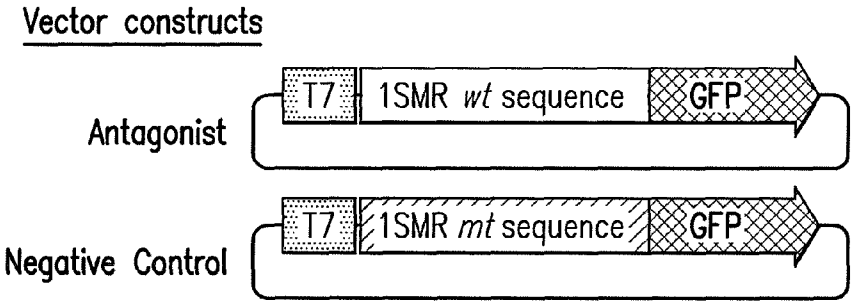
Vector constructs
Antagonist
T7
1SMR wt sequence
GFP
Negative Control
T7
1SMR mt sequence
GFP

FIG. 1B

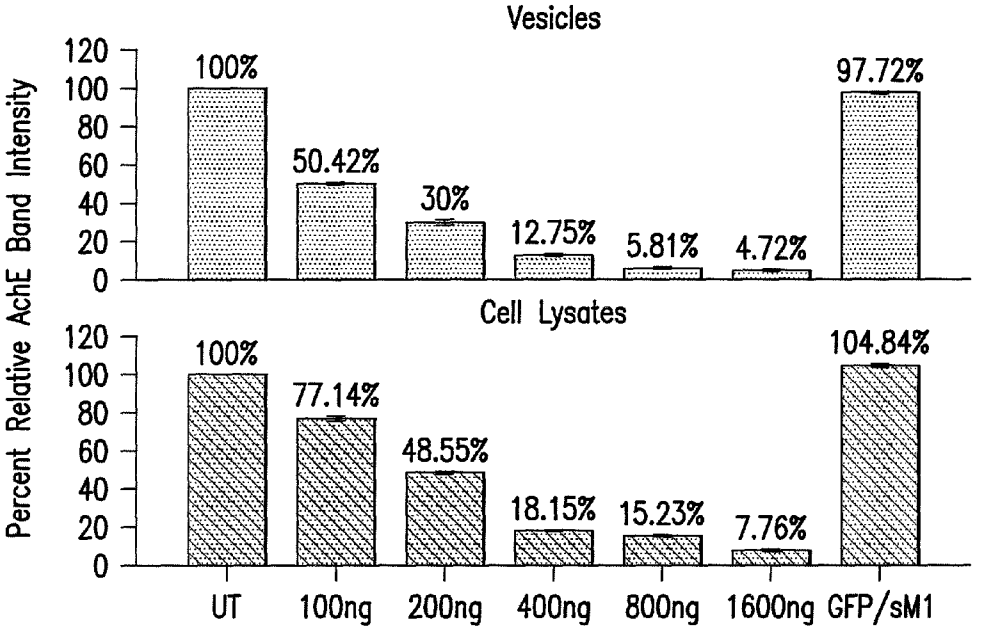
Vesicles
Percent Relative AchE Band Intensity
120
100
80
60
40
20
0
100%
50.42%
30%
12.75%
5.81%
4.72%
97.72%
Cell Lysates
100%
77.14%
48.55%
18.15%
15.23%
7.76%
104.84%
UT
100ng
200ng
400ng
800ng
1600ng
GFP/sM1

FIG.1C

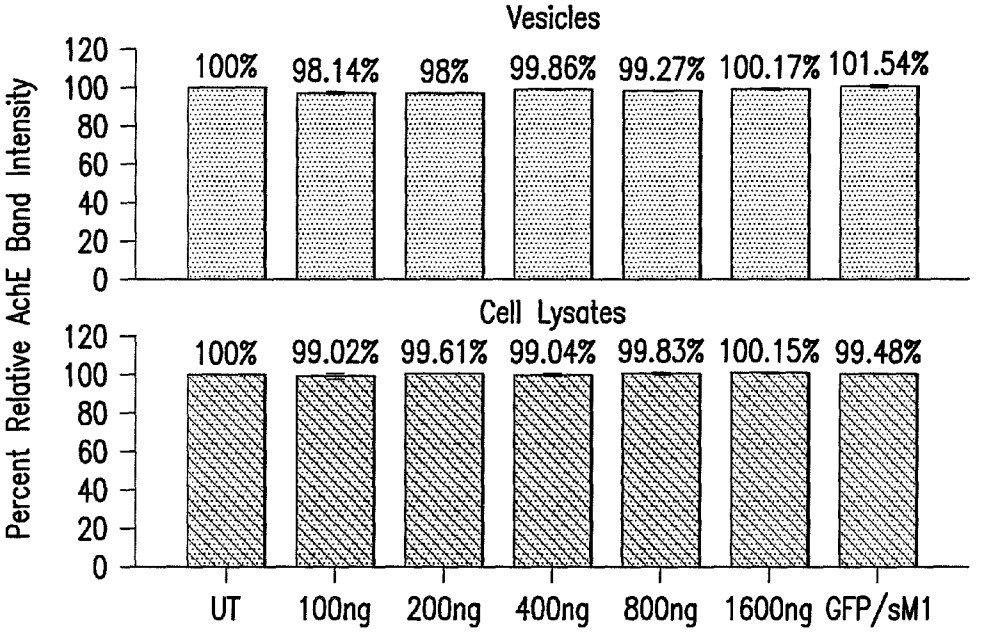
Vesicles
Percent Relative AchE Band Intensity
120
100
80
60
40
20
0
100%
98.14%
98%
99.86%
99.27%
100.17%
101.54%
Cell Lysates
100%
99.02%
99.61%
99.04%
99.83%
100.15%
99.48%
UT
100ng
200ng
400ng
800ng
1600ng
GFP/sM1

FIG.1D

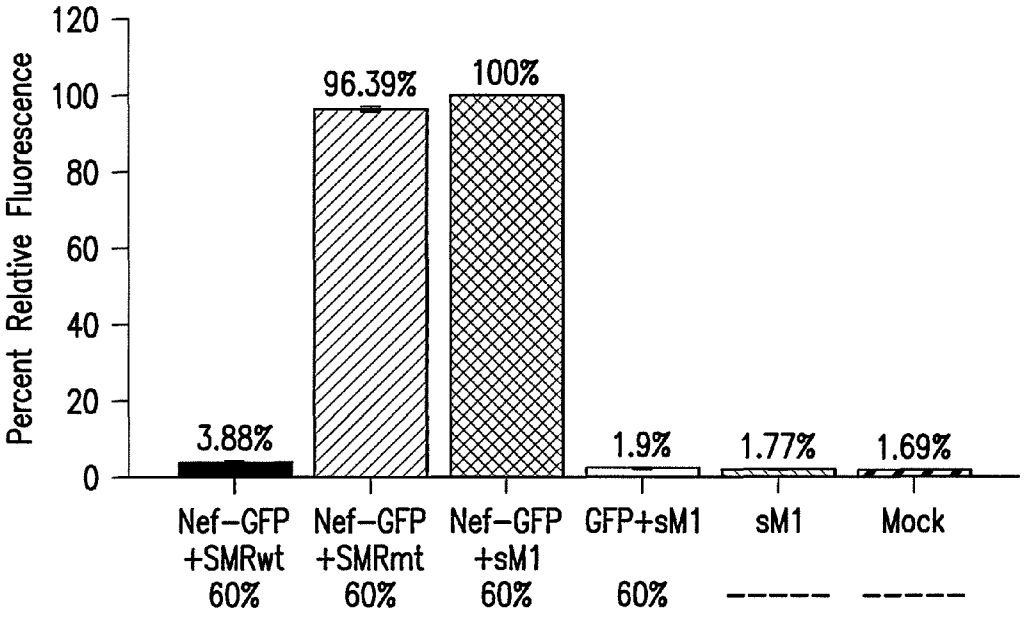
Percent Relative Fluorescence
120
100
80
60
40
20
0
3.88%
96.39%
100%
1.9%
1.77%
1.69%
Nef–GFP +SMRwt 60%
Nef–GFP +SMRmt 60%
Nef–GFP +sM1 60%
GFP+sM1 60%
sM1 -----
Mock -----

FIG.2

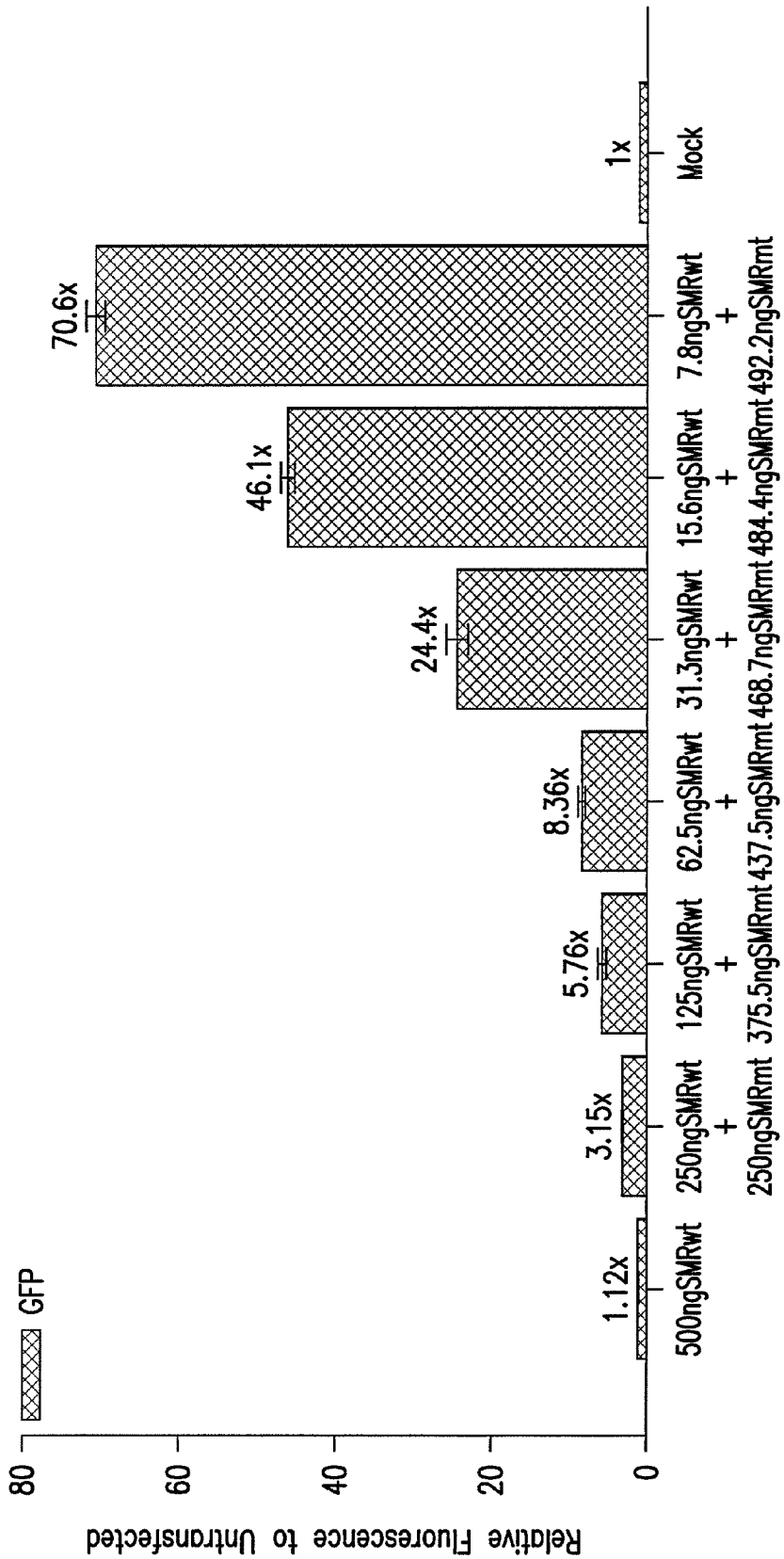
Relative Fluorescence to Untransfected
80
60
40
20
0
GFP
1.12x
3.15x
5.76x
8.36x
24.4x
46.1x
70.6x
1x
500ngSMRwt
250ngSMRwt + 250ngSMRmt
125ngSMRwt + 375.5ngSMRmt
62.5ngSMRwt + 437.5ngSMRmt
31.3ngSMRwt + 468.7ngSMRmt
15.6ngSMRwt + 484.4ngSMRmt
7.8ngSMRwt + 492.2ngSMRmt
Mock

FIG.3A

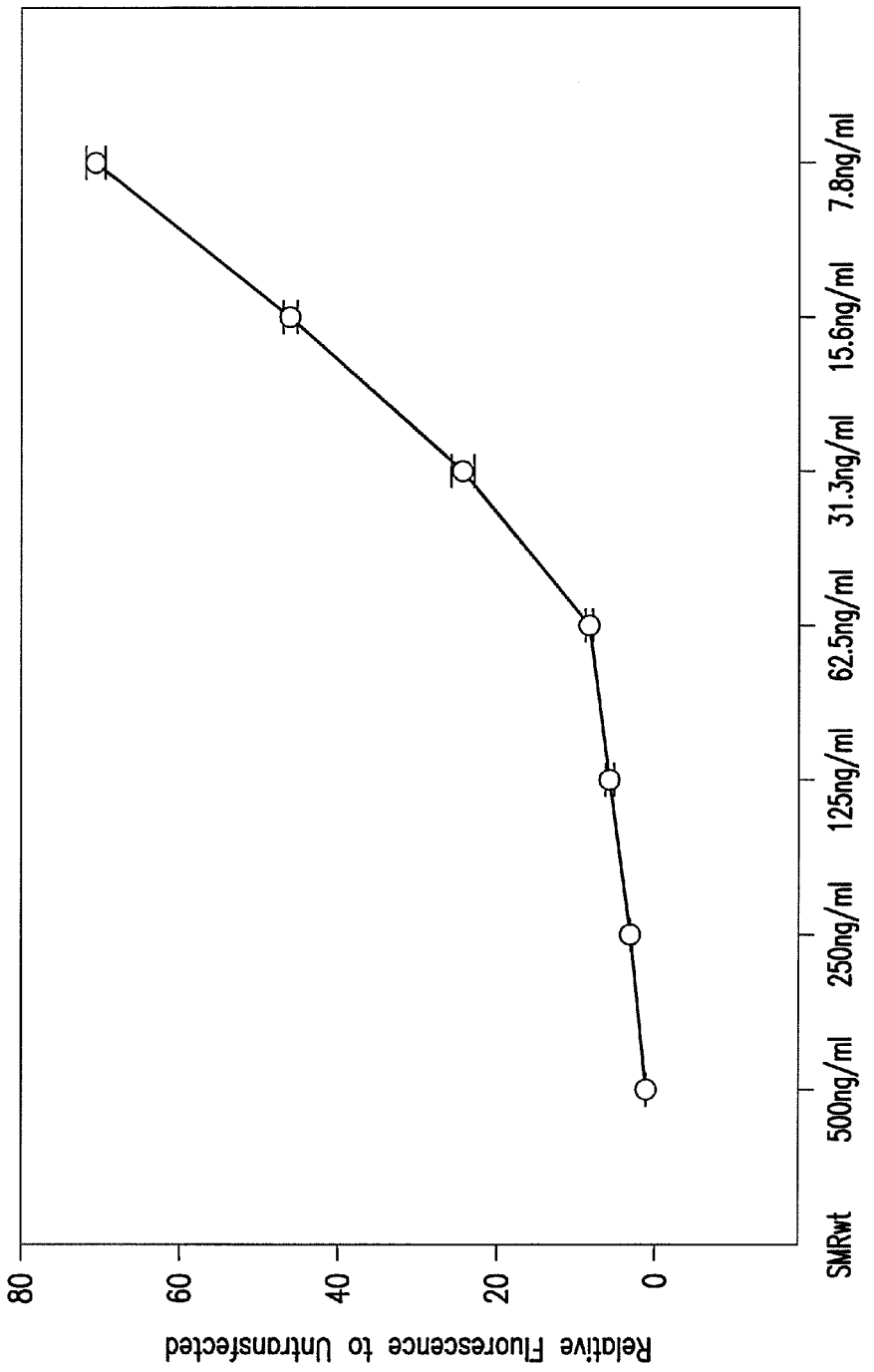
Relative Fluorescence to Untransfected
0
20
40
60
80
SMRwt
500ng/ml
250ng/ml
125ng/ml
62.5ng/ml
31.3ng/ml
15.6ng/ml
7.8ng/ml

FIG. 3B

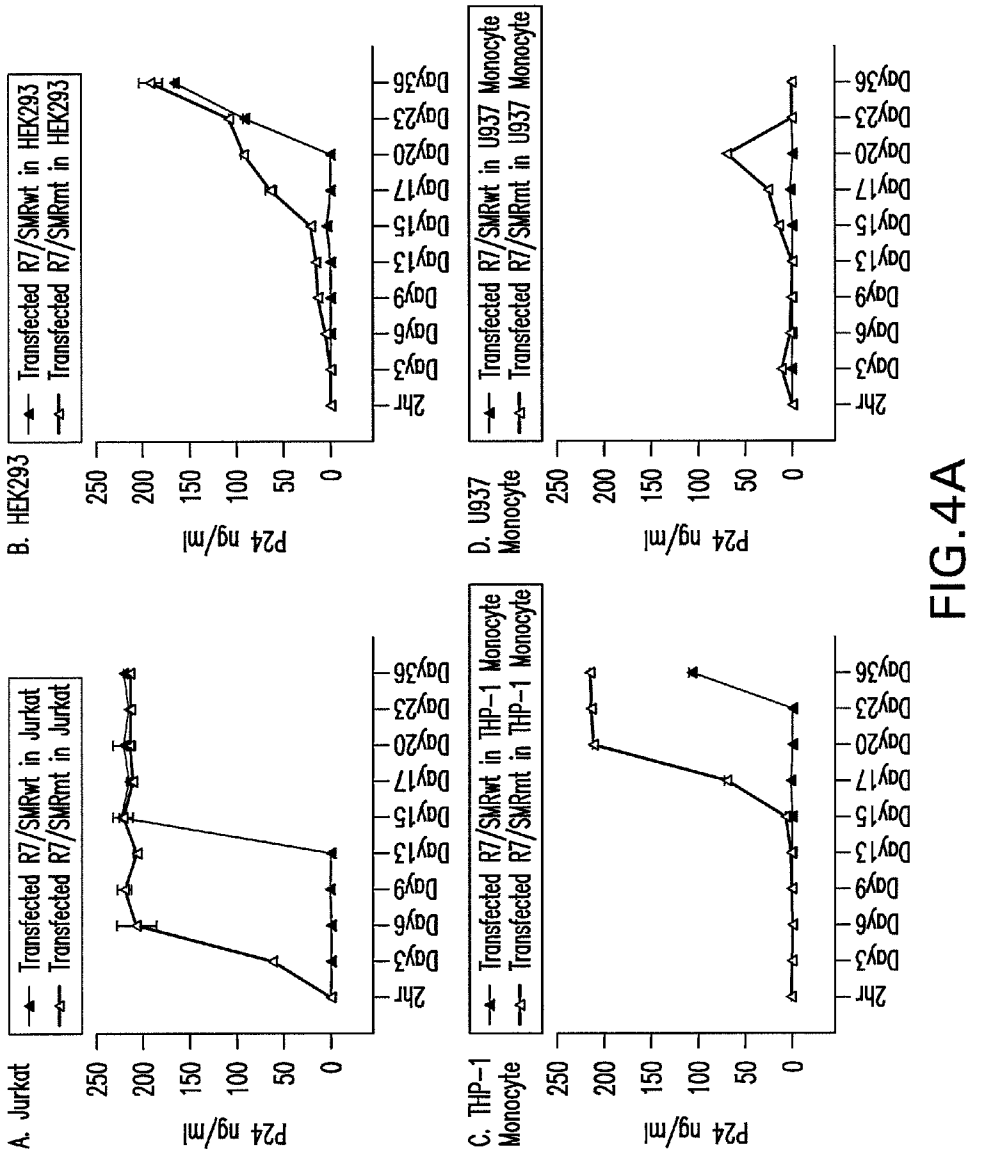
A. Jurkat
Transfected R7/SMRwt in Jurkat
Transfected R7/SMRmt in Jurkat
B. HEK293
Transfected R7/SMRwt in HEK293
Transfected R7/SMRmt in HEK293
C. THP-1 Monocyte
Transfected R7/SMRwt in THP-1 Monocyte
Transfected R7/SMRmt in THP-1 Monocyte
D. U937 Monocyte
Transfected R7/SMRwt in U937 Monocyte
Transfected R7/SMRmt in U937 Monocyte
P24 ng/ml
0
50
100
150
200
250
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day36

FIG.4A

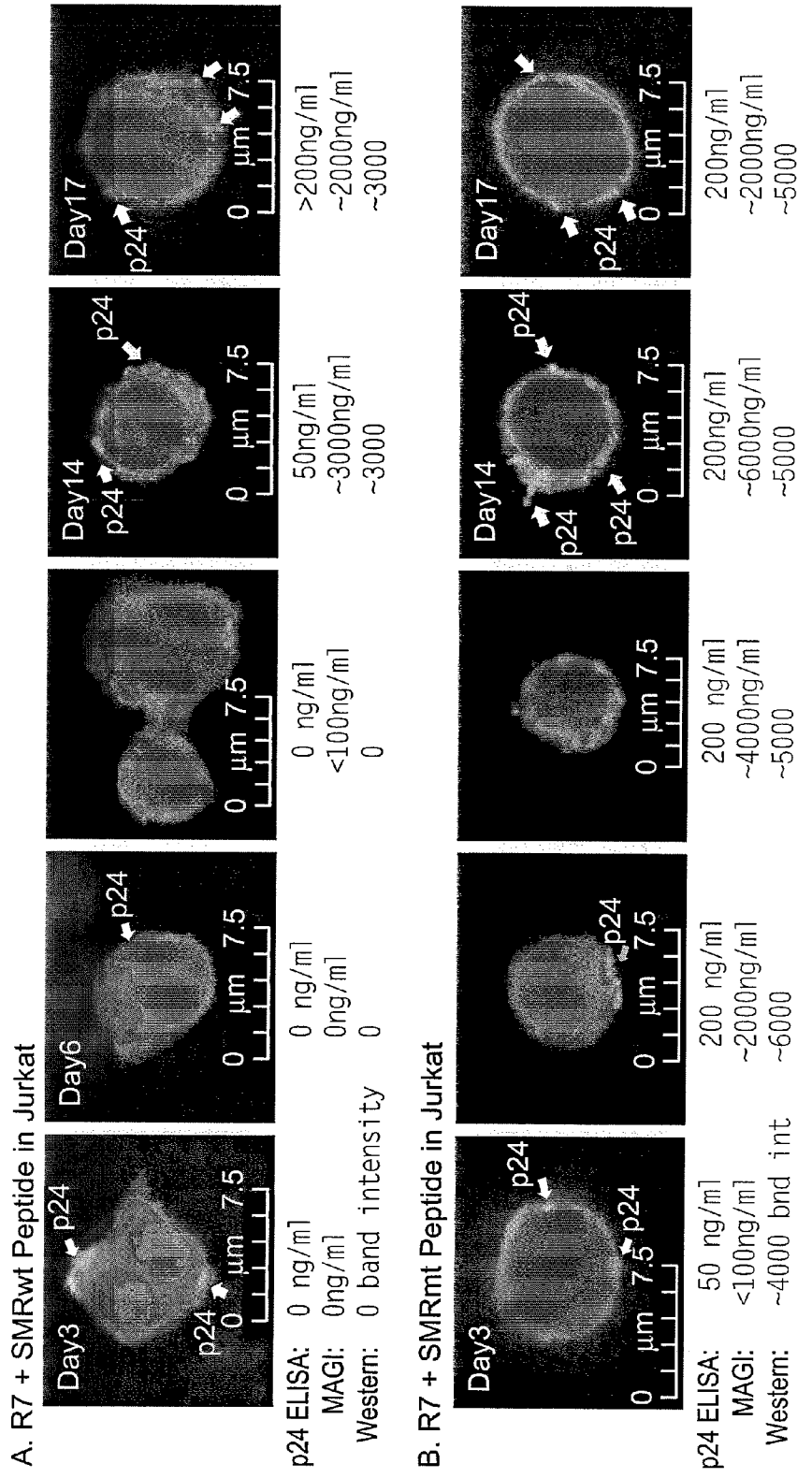
A. R7 + SMRwt Peptide in Jurkat
Day3
Day6
Day14
Day17
p24
0 µm 7.5
p24 ELISA: 0 ng/ml 0 ng/ml 50ng/ml >200ng/ml
MAGI: 0ng/ml 0ng/ml <100ng/ml ~3000ng/ml ~2000ng/ml
Western: 0 band intensity 0 ~3000 ~3000
B. R7 + SMRmt Peptide in Jurkat
p24 ELISA: 50 ng/ml 200 ng/ml 200 ng/ml 200ng/ml
MAGI: <100ng/ml ~2000ng/ml ~4000ng/ml ~6000ng/ml ~2000ng/ml
Western: ~4000 bnd int ~6000 ~5000 ~5000 ~5000

FIG.4B

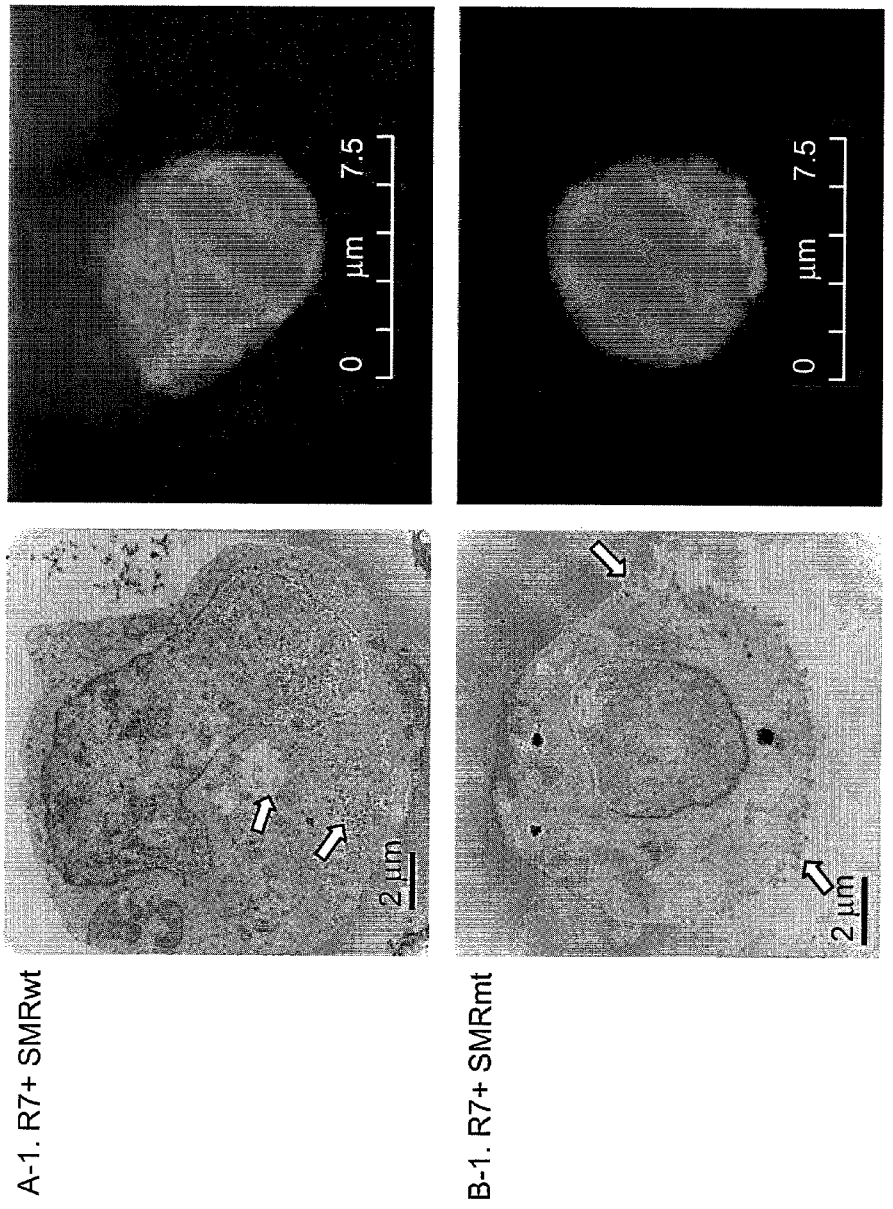

FIG.4C

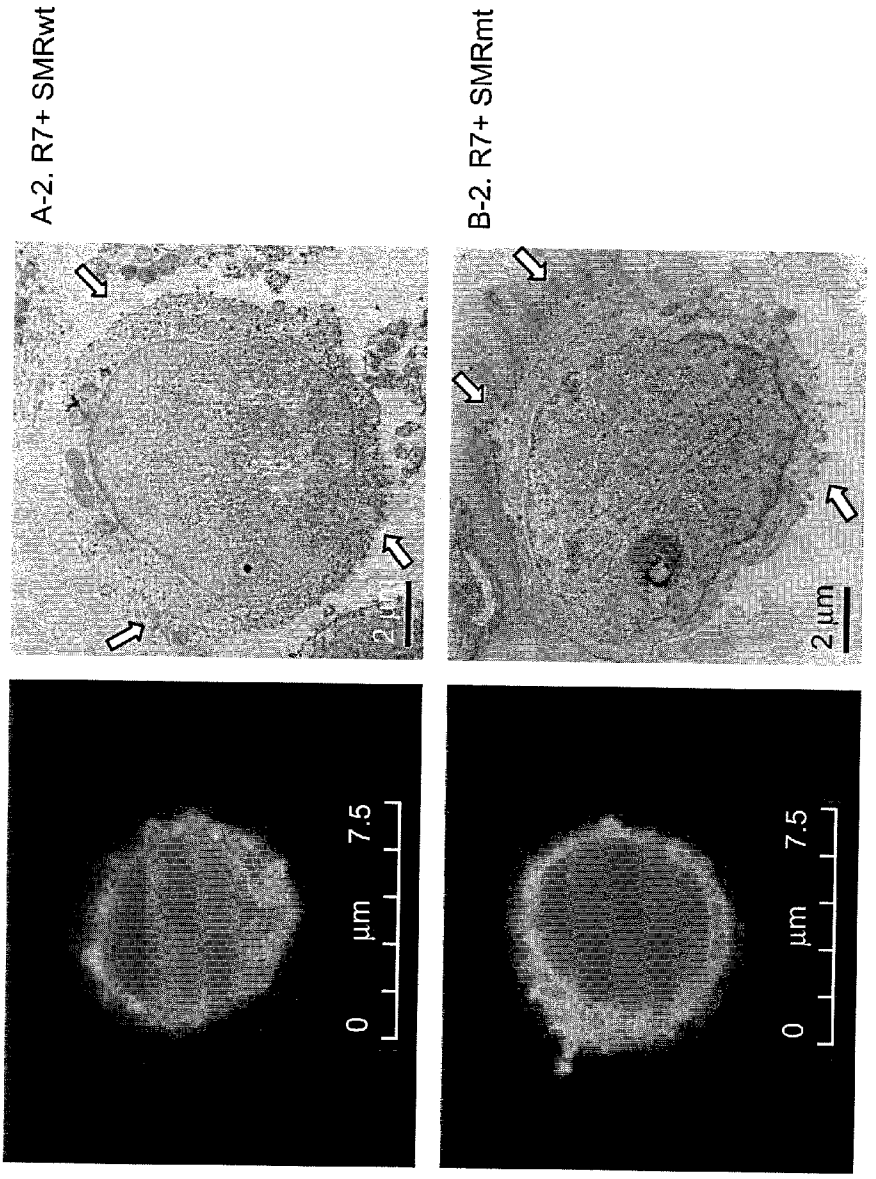

FIG.4D

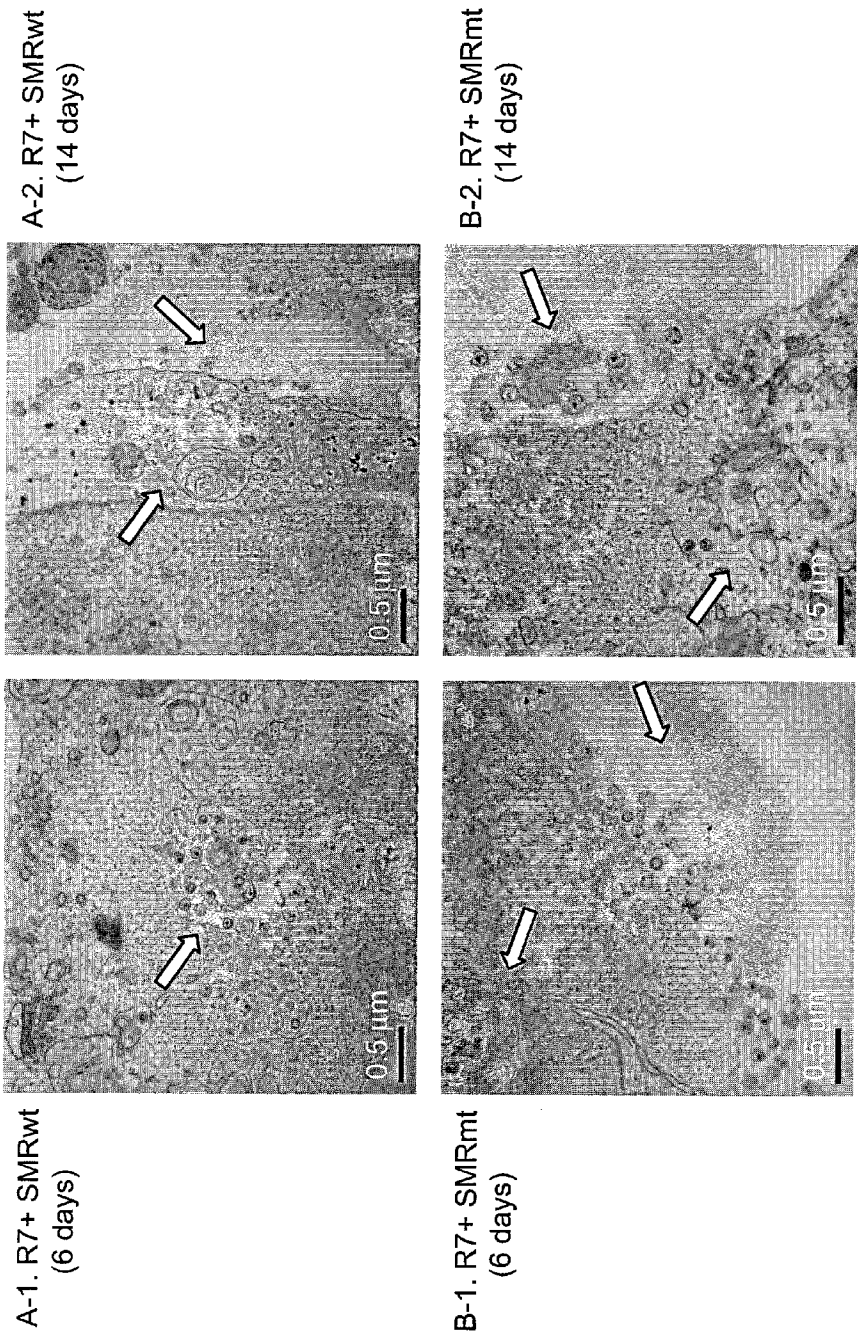
A-2. R7+ SMRwt
(14 days)
B-2. R7+ SMRmt
(14 days)
A-1. R7+ SMRwt
(6 days)
B-1. R7+ SMRmt
(6 days)
0.5 μm
0.5 μm
0.5 μm
0.5 μm

FIG.4E

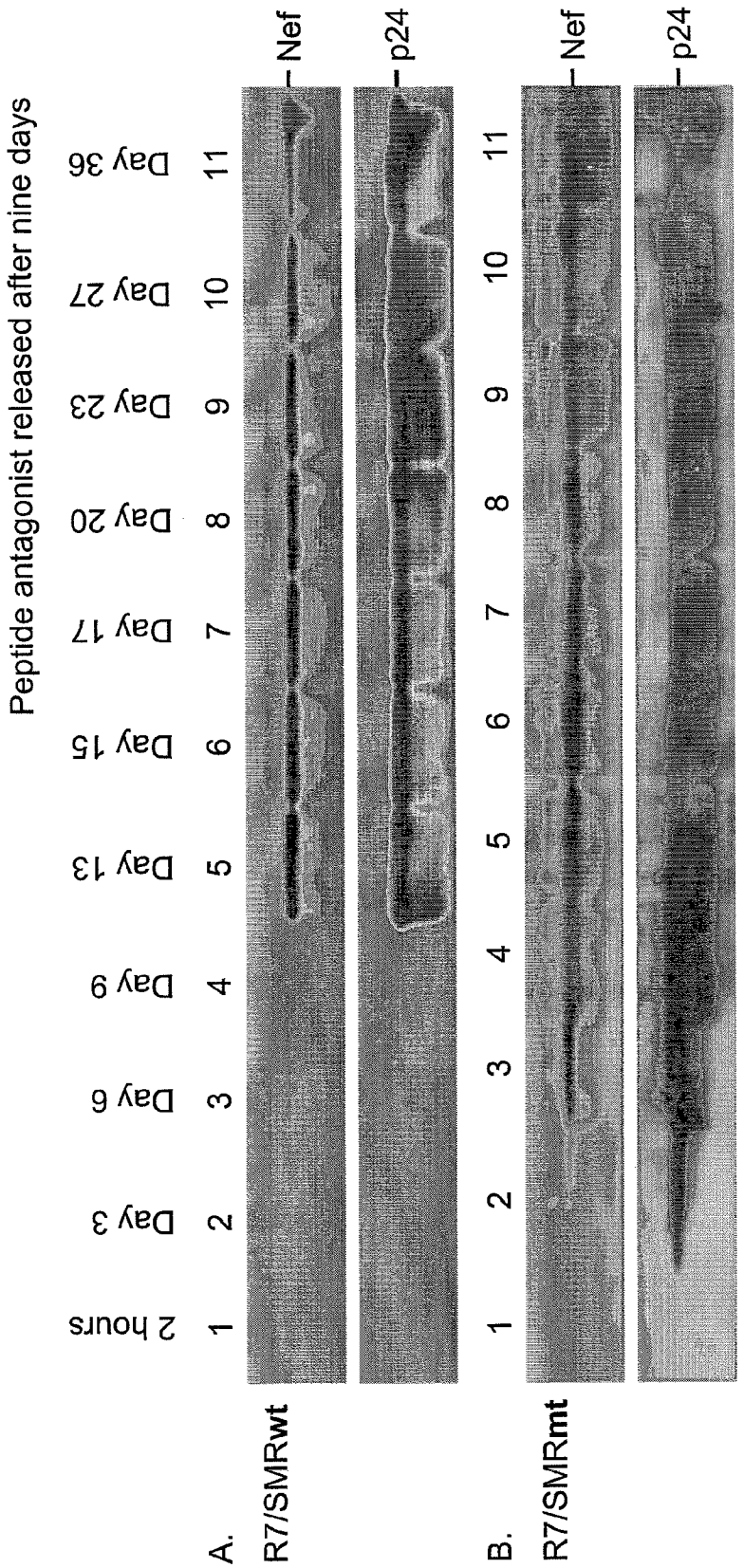
Peptide antagonist released after nine days
2 hours
Day 3
Day 6
Day 9
Day 13
Day 15
Day 17
Day 20
Day 23
Day 27
Day 36
1
2
3
4
5
6
7
8
9
10
11
A.
R7/SMRwt
Nef
p24
B.
R7/SMRmt
Nef
p24

FIG.5

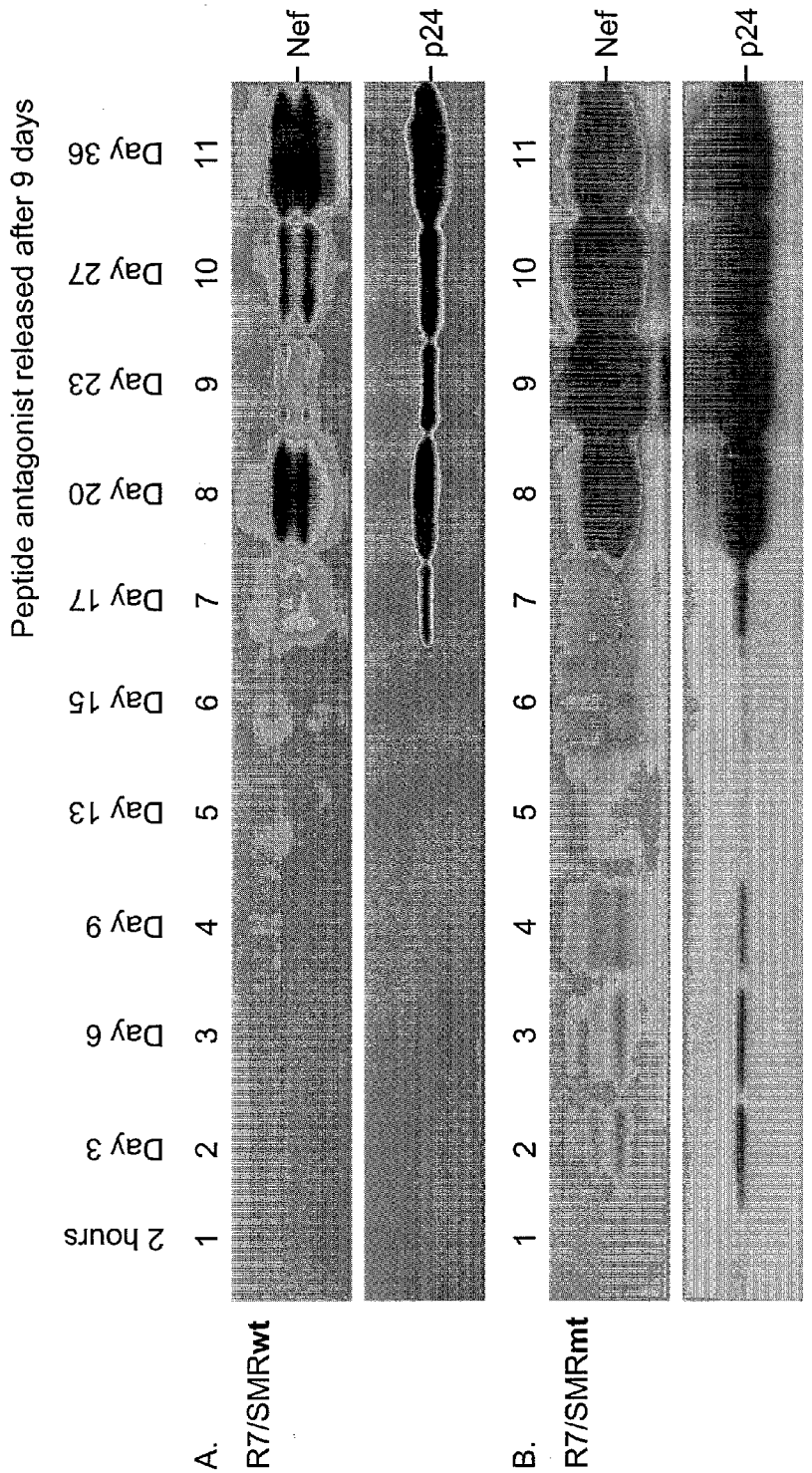
Peptide antagonist released after 9 days
2 hours
Day 3
Day 6
Day 9
Day 13
Day 15
Day 17
Day 20
Day 23
Day 27
Day 36
1
2
3
4
5
6
7
8
9
10
11
A.
R7/SMRwt
Nef
p24
B.
R7/SMRmt
Nef
p24

FIG.6

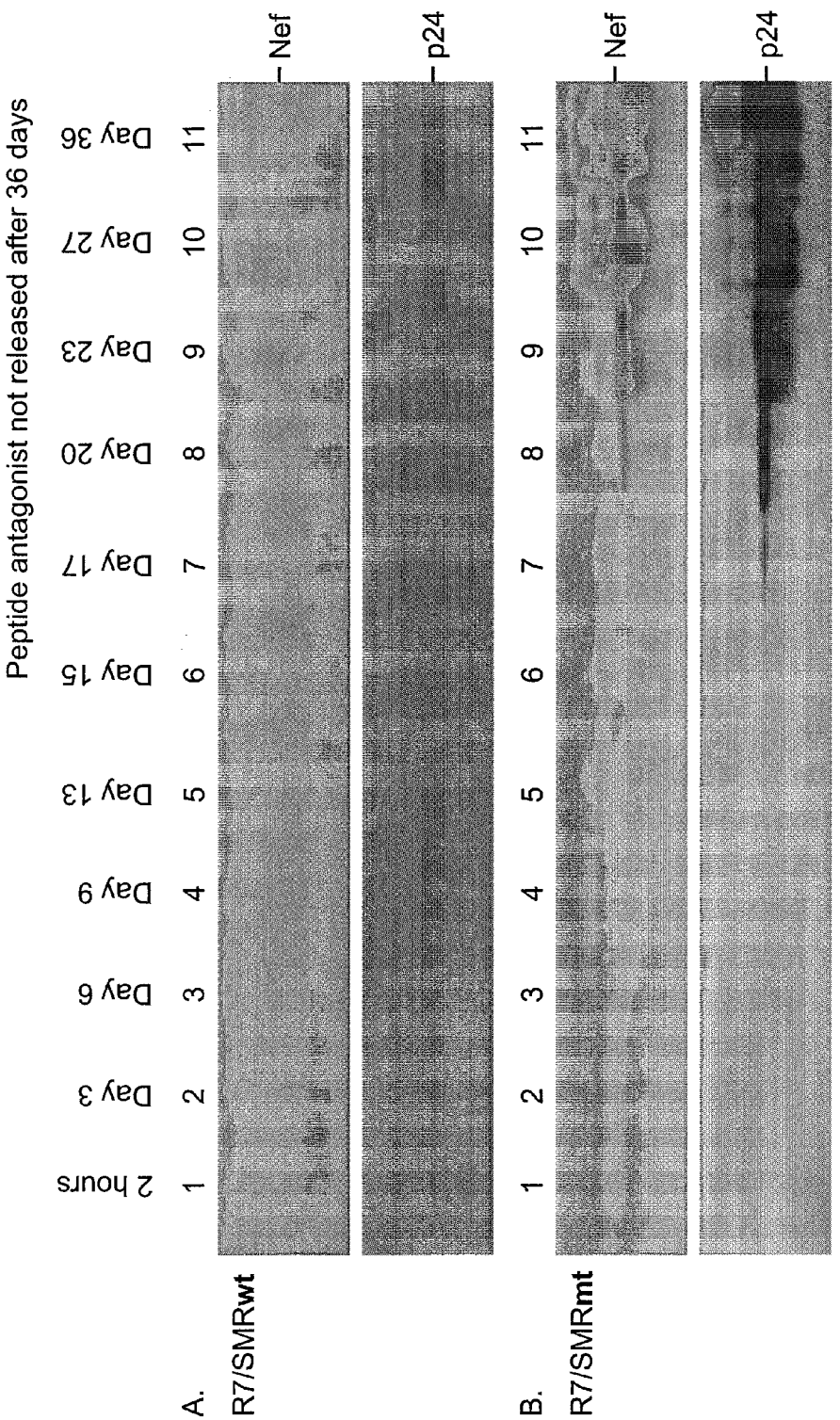
Peptide antagonist not released after 36 days
2 hours
Day 3
Day 6
Day 9
Day 13
Day 15
Day 17
Day 20
Day 23
Day 27
Day 36
1
2
3
4
5
6
7
8
9
10
11
A.
R7/SMRwt
B.
R7/SMRmt
Nef
p24
Nef
p24

FIG. 7

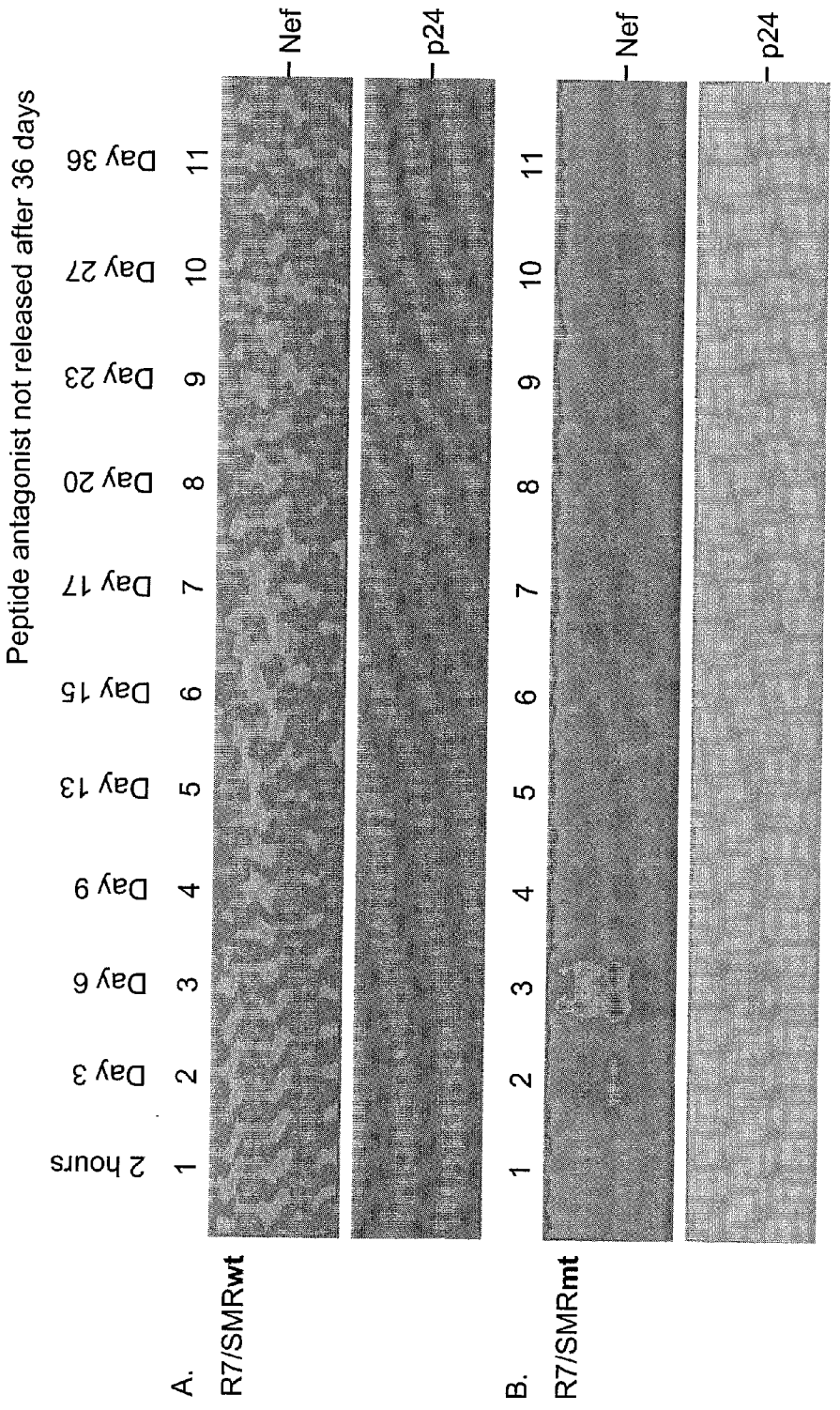
Peptide antagonist not released after 36 days
2 hours
Day 3
Day 6
Day 9
Day 13
Day 15
Day 17
Day 20
Day 23
Day 27
Day 36
1
2
3
4
5
6
7
8
9
10
11
A.
R7/SMRwt
Nef
p24
B.
R7/SMRmt
Nef
p24

FIG.8

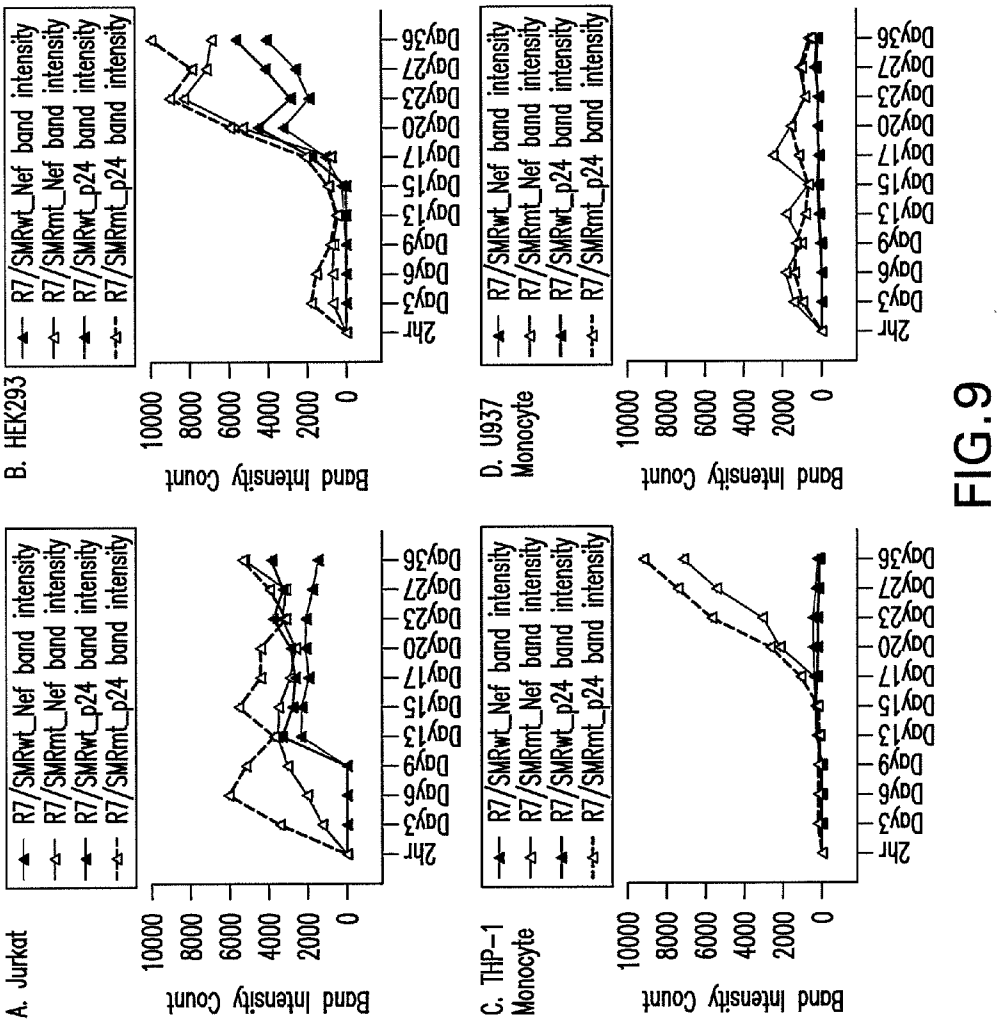
A. Jurkat
B. HEK293
C. THP-1 Monocyte
D. U937 Monocyte
R7/SMRwt_Nef band intensity
R7/SMRmt_Nef band intensity
R7/SMRwt_p24 band intensity
R7/SMRmt_p24 band intensity
Band Intensity Count
10000
8000
6000
4000
2000
0
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day27
Day36

FIG.9

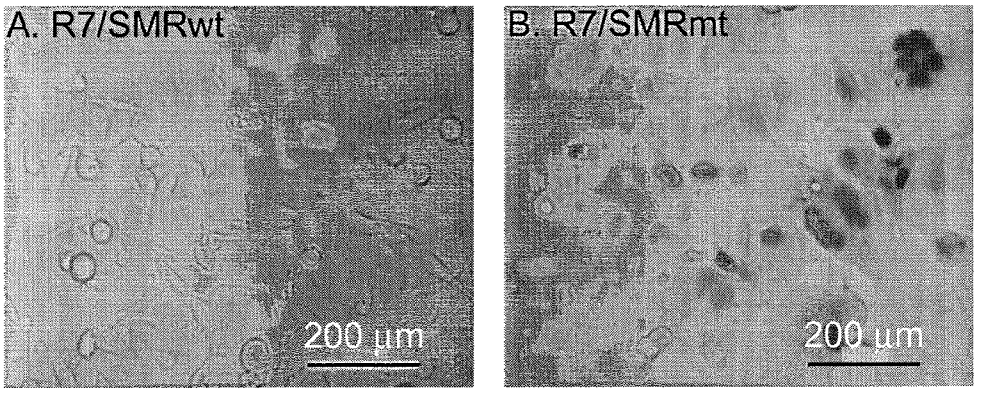

FIG.10

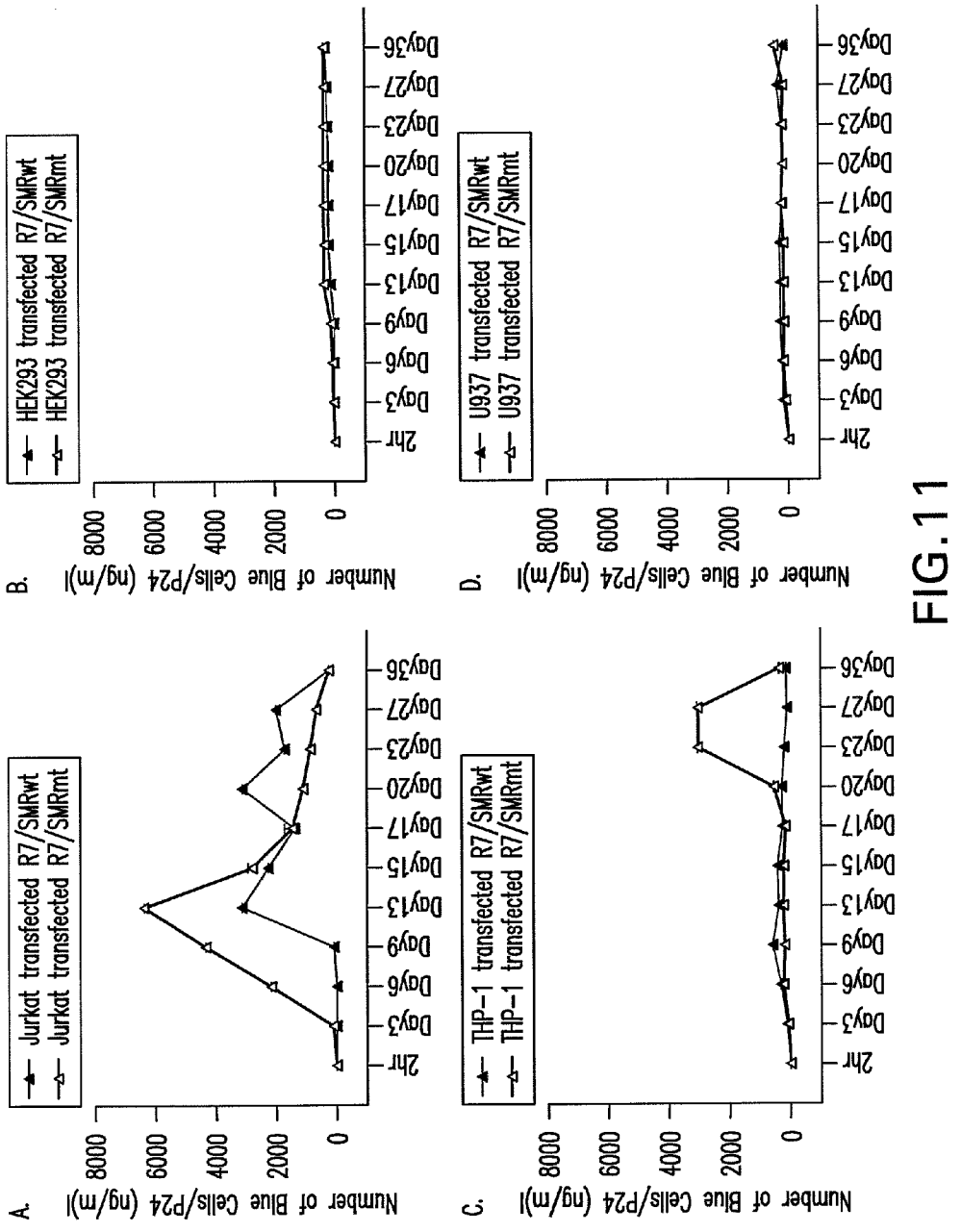
A.
Number of Blue Cells/P24 (ng/ml)
8000
6000
4000
2000
0
Jurkat transfected R7/SMRwt
Jurkat transfected R7/SMRmt
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day27
Day36
B.
Number of Blue Cells/P24 (ng/ml)
8000
6000
4000
2000
0
HEK293 transfected R7/SMRwt
HEK293 transfected R7/SMRmt
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day27
Day36
C.
Number of Blue Cells/P24 (ng/ml)
8000
6000
4000
2000
0
THP-1 transfected R7/SMRwt
THP-1 transfected R7/SMRmt
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day27
Day36
D.
Number of Blue Cells/P24 (ng/ml)
8000
6000
4000
2000
0
U937 transfected R7/SMRwt
U937 transfected R7/SMRmt
2hr
Day3
Day6
Day9
Day13
Day15
Day17
Day20
Day23
Day27
Day36

FIG. 11

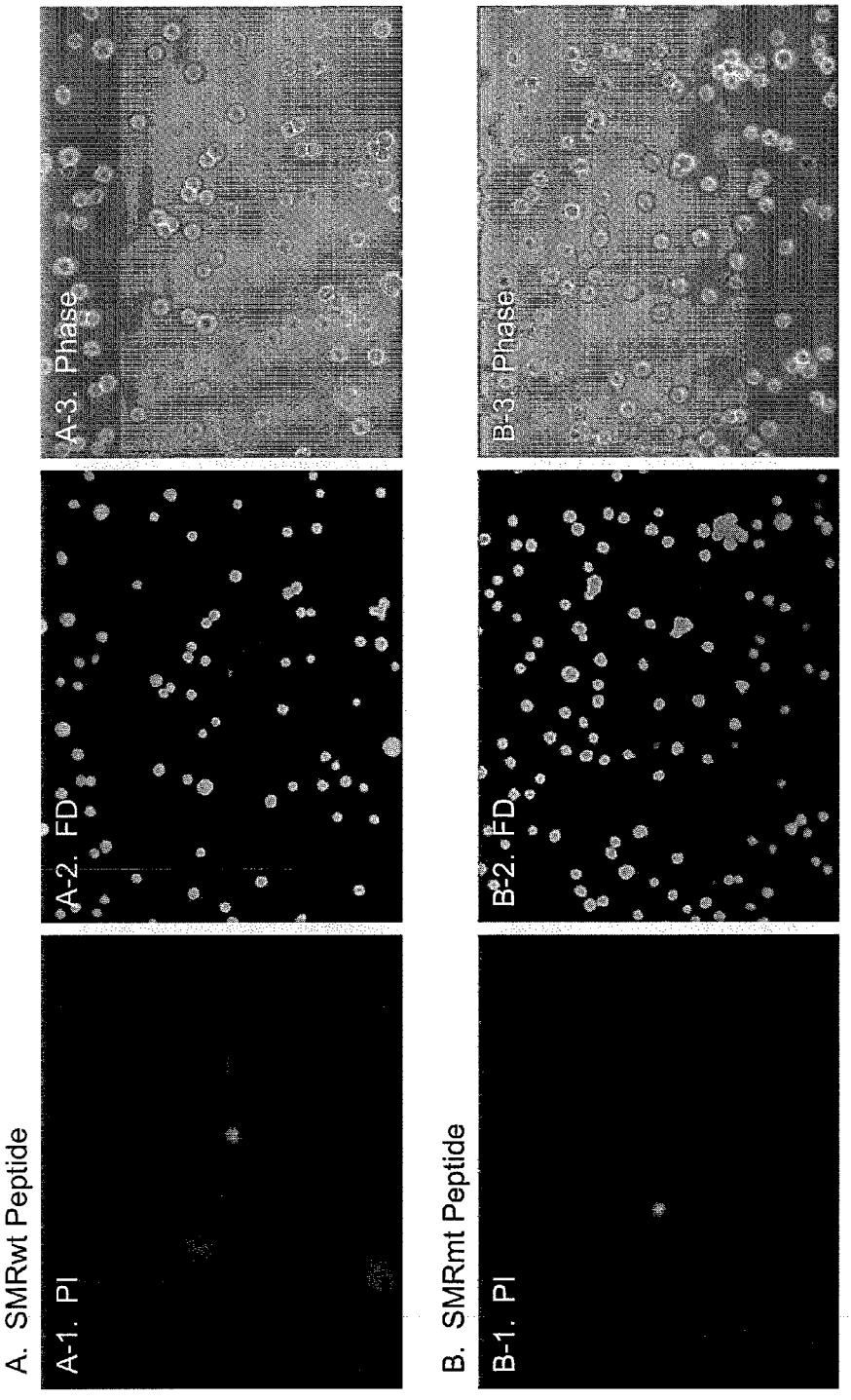
A. SMRwt Peptide
A-1. PI
A-2. FD
A-3. Phase
B. SMRmt Peptide
B-1. PI
B-2. FD
B-3. Phase

FIG. 12

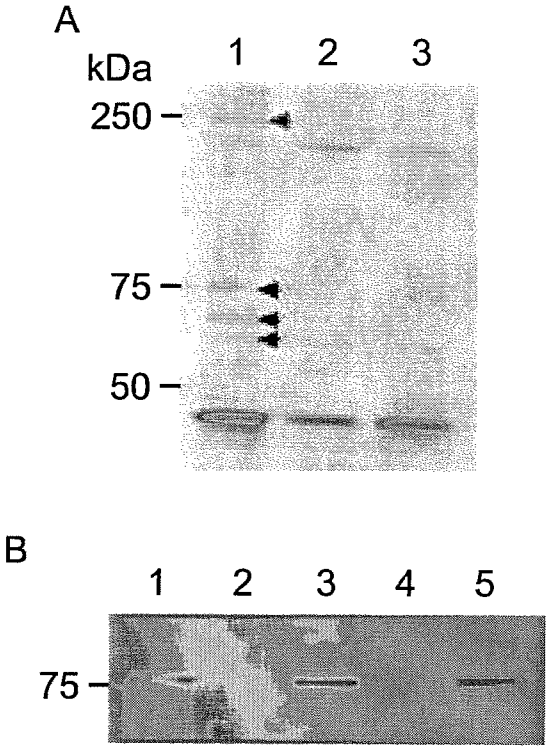

FIG.13

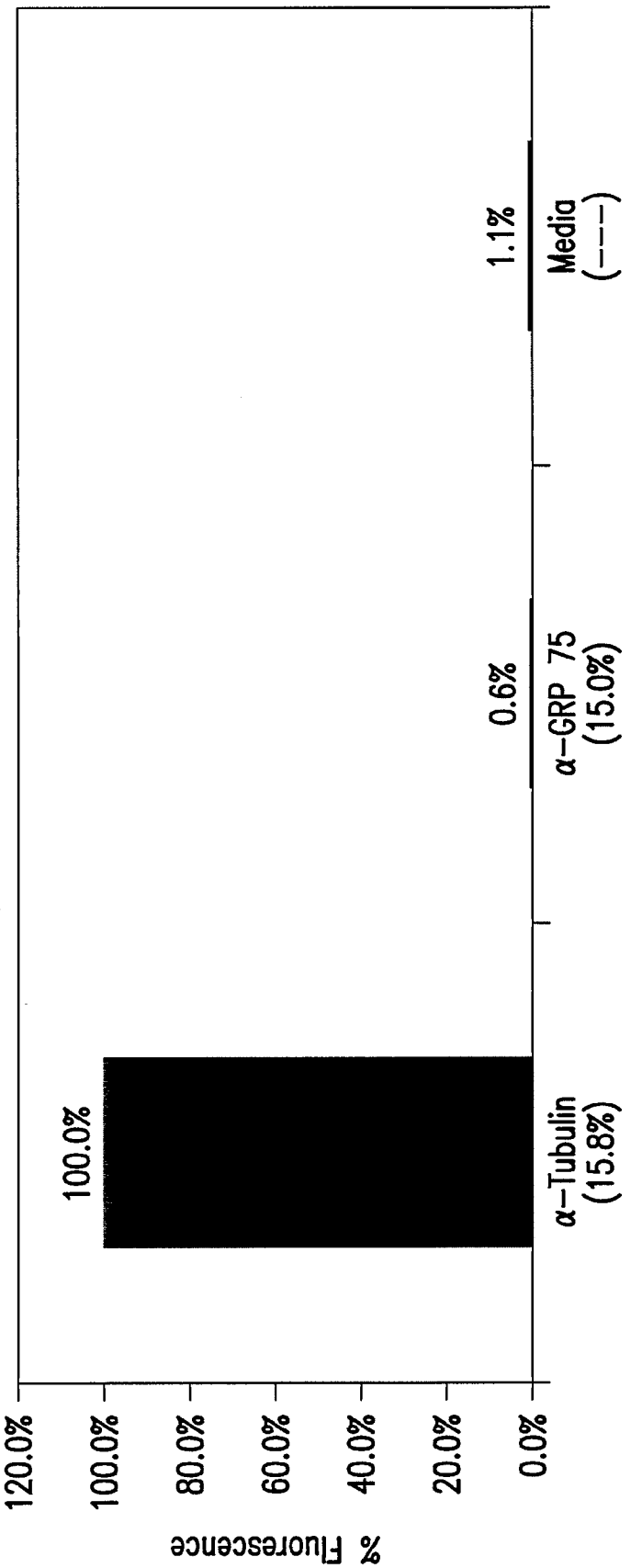
Antibody Inhibition of Nef Secretion: GRP 75
% Fluorescence
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
100.0%
0.6%
1.1%
α–Tubulin (15.8%)
α–GRP 75 (15.0%)
Media (---)

FIG. 14

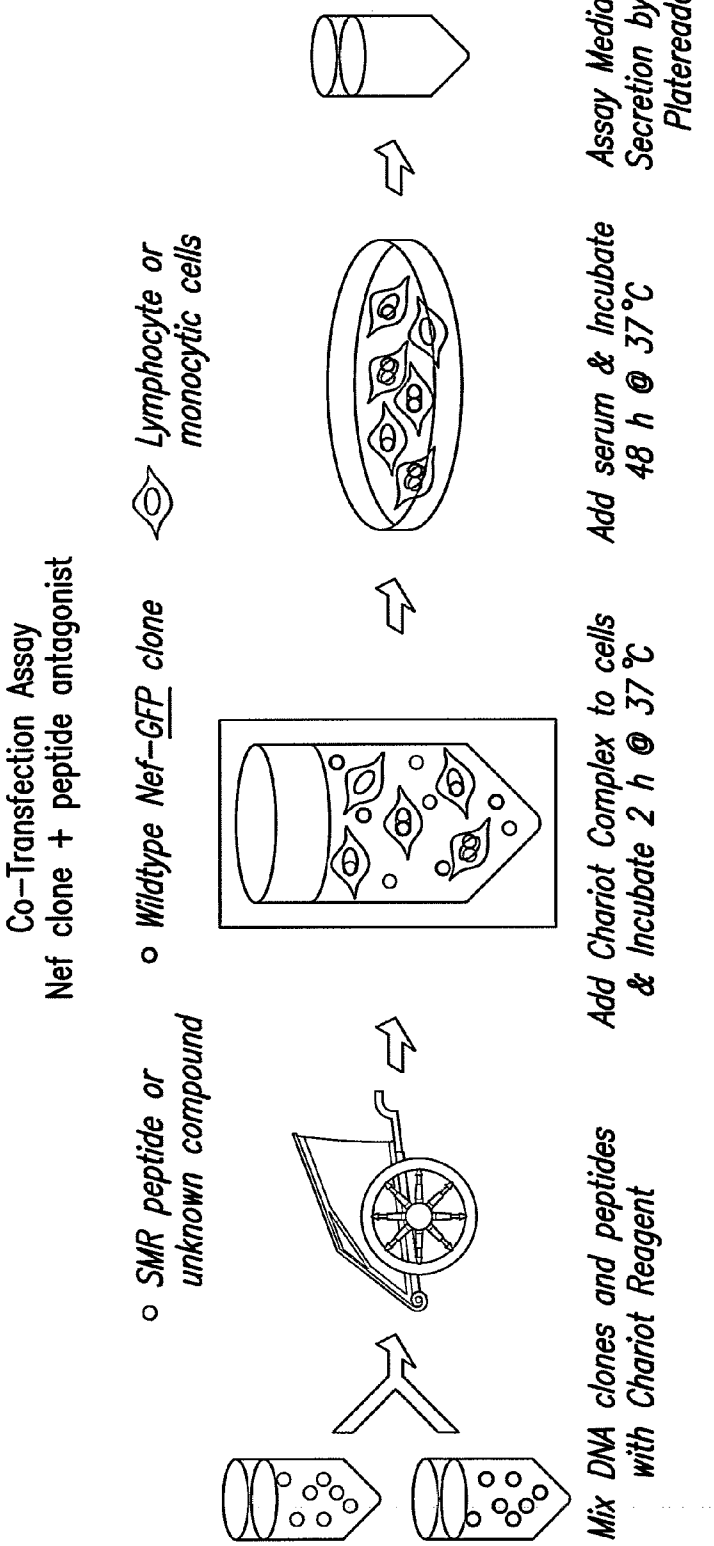
Co–Transfection Assay
Nef clone + peptide antagonist
o SMR peptide or unknown compound
o Wildtype Nef–GFP clone
Lymphocyte or monocytic cells
Mix DNA clones and peptides with Chariot Reagent
Add Chariot Complex to cells & Incubate 2 h @ 37 °C
Add serum & Incubate 48 h @ 37°C
Assay Media for Secretion by Fl–Platereader

FIG. 15

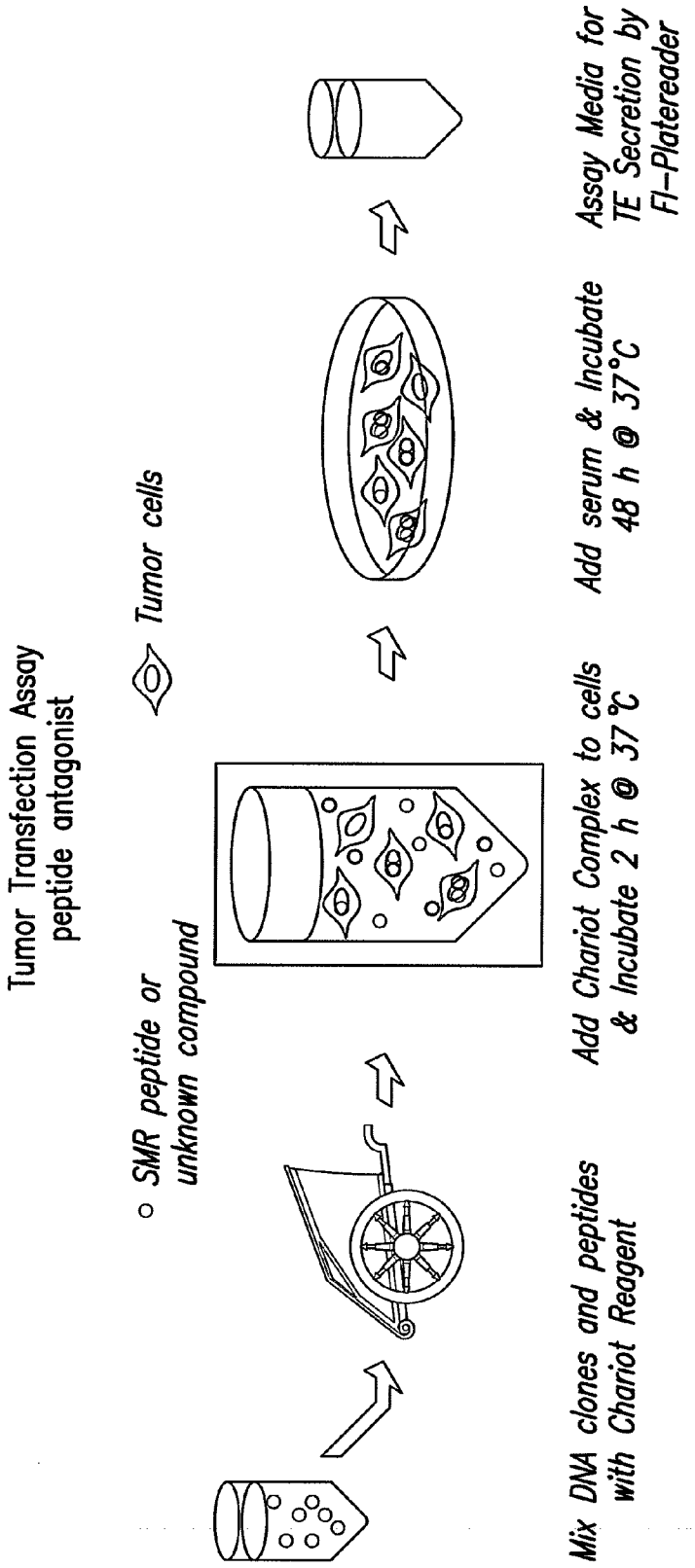
Tumor Transfection Assay
peptide antagonist
SMR peptide or unknown compound
Tumor cells
Mix DNA clones and peptides with Chariot Reagent
Add Chariot Complex to cells & Incubate 2 h @ 37°C
Add serum & Incubate 48 h @ 37°C
Assay Media for TE Secretion by Fl-Platereader

FIG. 16

COMPOSITIONS AND METHODS FOR TREATING AIDS OR CANCER BY INHIBITING THE SECRETION OF MICROPARTICLES

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/783,829, filed May 20, 2010, which claims priority from Provisional Patent Application 61/213,471 filed Jun. 12, 2009. The entirety of the aforementioned applications is incorporated herein by reference.

FIELD

The present invention generally relates to medical treatment and, in particular, to a method for treating AIDS or tumors by inhibiting the secretion of microparticles.

BACKGROUND

Membrane vesicles are spherical membrane microparticles, generally less than 200 nm in diameter. The microparticles are composed of a lipid bilayer containing a cytosolic fraction. Particular membrane vesicles are more specifically produced by cells, from intracellular compartments through fusion with the cytoplasmic membrane of a cell, resulting in their release into the extracellular biological fluids of an organism or into the supernatant of cells in culture. These vesicles/microparticles may be released in a number of ways. The classical secretory pathway processes mainly traditional membrane signals bearing receptors through the Endoplasmic Reticulum (ER) membrane (Lee et al., (2004) Annu. Rev. Cell Dev. Biol. 20, 87-123).

The secretory proteins are packaged into transport vesicles, delivered to the Golgi apparatus, and eventually released of into the extracellular space.

Alternatively, nonclassical secretory pathways exist and mediate translocation of cytosolic, nonsignal bearing molecules into the extracellular space (Lippincott-Schwartz et al., (1989) Cell 56, 801-813; and Misumi et al., (1986) J. Biol. Chem. 261, 11398-11403). Two of these involve intracellular vesicles of the endocytic membrane system, such as secretory lysosomes (Muesch et al., (1990) Trends Biochem. Sci. 15, 86-88) and exosomes (Johnstone et al., (1987) J. Biol. Chem. 262, 9412-9420), the latter ones being internal vesicles of late endosomes or multivesicular bodies (MVB). Lysosomal contents gain access to the exterior of cells when specialized endocytic structures such as secretory lysosomes of cytotoxic T lymphocytes fuse with the plasma membrane. Lumenal contents of late endocytic structures are released into the extracellular space when MVBs fuse with the plasma membrane resulting in release of the internal multivesicular endosomes into the extracellular space (called exosomes) along with their cargo molecules. Other nonclassical pathways involve direct translocation of cytosolic factors across the plasma membrane using protein conducting channels or a process called membrane blebbing (Nickel, W. (2005) Traffic. 6, 607-614). Membrane blebbing is characterized by shedding of plasma membrane-derived microvesicles into the extracellular space.

Microparticle release has been demonstrated from different cell types in varied physiological contexts. It has been demonstrated that tumor cells secrete microparticles, such as exosomes; texosomes, Tex or tumor exosomes (Yu et al., (2007) J. Immunol. 178, 6867-6875) in a regulated manner, carrying tumor antigens and capable of presenting these antigens or transmitting them to antigen presenting cells (patent application No. WO99/03499). These microparticles are released by tumor cells and cause immune suppression through immune cell killing or deregulation allowing tumor growth. Release of these FasL or TNF containing exosomes has been found to be one mechanism by which the tumor promotes a state of immune privilege/immune suppression. Alternatively, it has shown that HIV infected cells release Nef-containing vesicles (Guy et al., (1990) Virology 176, 413-425; and Campbell et al., (2008) Ethn. Dis. 18, S2-S9). We postulate that these vesicles are similarly used by HIV to dysregulate the immune system allowing HIV to survive. Finally, the endosomal trafficking pathway has been suggested to also be involved in virion release from infected cells (Sanfridson et al., (1997) Proc. Natl. Acad. Sci. U.S.A 94, 873-878; and Esser et al., (2001) J Virol. 75, 6173-6182). Thus, during the HIV infection, the endosomal pathway, involved in several vesicle release pathways, serves a dual function in both regulation of the immune system and in virion release of infected cells. It would be of particular interest to have an effective method that could be used to dampen or inhibit microparticle/vesicle release.

SUMMARY

One aspect of the present invention relates to a novel peptide that inhibits the release of microparticles from cells. The peptide has a length of 10-100 amino acids and contains (1) at least one VGFPV (SEQ ID NO: 1) motif at the N-terminal, or (2) at least one VGFPV (SEQ ID NO: 1) motif at the C-terminal, or (3) at least two VGFPV (SEQ ID NO: 1) motifs.

In one embodiment, the peptide contains at least one VGFPV (SEQ ID NO: 1) motif at the N-terminal. In another embodiment, the peptide contains at least one VGFPV (SEQ ID NO: 1) motif at the C-terminal. In another embodiment, the peptide contains at least two VGFPV (SEQ ID NO: 1) motifs. In another embodiment, the peptide contains the amino acid sequence VGFPVAAVGFPV (SEQ ID NO: 2). In yet another embodiment, the peptide has the sequence of H2N-VGFPVAAVGFPVDYKDDDDK-OH (SEQ ID NO: 3).

Another aspect of the present invention relates to a polynucleotide encoding the novel peptide of the present invention and an expression vector carrying a polynucleotide encoding the novel peptide of the present invention.

Another aspect of the present invention relates to a pharmaceutical composition for treating AIDS or tumors. The pharmaceutical composition comprises (1) a peptide has a length of 10-100 amino acids and contains (a) at least one VGFPV (SEQ ID NO: 1) motif at the N-terminal, or (b) at least one VGFPV (SEQ ID NO: 1) motif at the C-terminal, or (c) at least two VGFPV (SEQ ID NO: 1) motifs or an expression vector encoding such a peptide, and (2) a pharmaceutically acceptable carrier.

Another aspect of the present invention relates to a method for treating AIDS. The method comprises administering to a subject in need of such treatment an effective amount of a peptide containing at least one SEQ ID NO: 1 motif and having a length of 10-100 amino acids.

Another aspect of the present invention relates to a method for treating tumors. The method comprises administering to a subject in need of such treatment an effective amount of a peptide containing at least one SEQ ID NO: 1 motif and having a length of 10-100 amino acids.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a composite of diagrams showing the synthetic HIV-1 NefSMRwt peptide (antagonist) and HIV-1 NefSM-

Rmt peptide (negative control) (panel A); the vector constructs expressing HIV-1 NefSMRwt peptide fused with GFP or HIV-1 NefSMRmt peptide fused with GFP (panel B); and the amount of acetylcholinesterase, a marker for exosomes, in MDA-MB-231 cells transfected with either HIV-1 NefSMRwt peptide (panel C) or SMRmt peptide (panel D). Untransfected MDA-MB-231 cells were used as negative controls. The cells were cultured for 48 hours in serum-free medium. One ml of supernatant was spun at 400,000×g. Supernatant pellets or set volume of cell lysate were run on PAGE, blotted, and probed with anti-AchE mAb (Acetylcholinesterase—1:1000 dilution; marker for exosomes). The cell lysates were reprobed with anti-Tubulin mAb (1:4000). Bands were measured by densitometry, normalized against intracellular tubulin. Data shown here as percent relative to the untransfected control.

FIG. **2** is a diagram showing that the HIV-1 NefSMRwt peptide antagonizes the release of NefGFP in HEK293 cells.

FIGS. **3**A and **3**B are diagrams showing that the HIV-1 NefSMRwt peptide antagonizes the release of NefGFP in Jurkat cells.

FIG. **4**A is a composite of diagrams showing ELISA analysis of p24 concentration in Jurkat cells (panel A), HEK293 cells (panel B), THP-1 Monocytes (panel C) and U937 monocytes (panel D). FIG. **4**B is a composite of confocal microscope pictures showing blocking of p24 release in Jurkat cells by SMRwt peptide (panel A) but not by SMRrmt peptide (panel B). FIG. **4**C is a composite of confocal and electron microscope pictures showing viral particle distribution in Jurkat cells at day 6 post-transfection with R7 and SMRwt peptide (panel A-1) or with R7 and SMRmt peptide (panel B-1). FIG. **4**D is a composite of confocal and electron microscope pictures showing viral particle distribution in Jurkat cells at day 14 post-transfection with R7 and SMRwt peptide (panel A-2) or with R7 and SMRmt peptide (panel B-2), FIG. **4**E is a composite of confocal and electron microscope pictures showing viral particle distribution in subcellular structures in Jurkat cells at day 6 post-transfection with R7 and SMRwt peptide (panel A-1) or with R7 and SMRmt peptide (panel B-1) in Jurkat cells and at day 14 post-transfection with R7 and SMRwt peptide (panel A-2) or with R7 and SMRmt peptide (panel B-2) in Jurkat cells.

FIG. **5** is a composite of pictures showing the Western blot analysis of Nef and p24 in Jurkat cells transfected with R7/SMRwt (panel A) or R7/SMRmt (panel B).

FIG. **6** is a composite of pictures showing the Western blot analysis of Nef and p24 in HEK293 cells transfected with R7/SMRwt (panel A) or R7/SMRmt (panel B).

FIG. **7** is a composite of pictures showing the Western blot analysis of Nef and p24 in THP-1 monocyte transfected with R7/SMRwt (panel A) or R7/SMRmt (panel B).

FIG. **8** is a composite of pictures showing the Western blot analysis of Nef and p24 in U937 monocyte transfected with R7/SMRwt (panel A) or R7/SMRmt (panel B).

FIG. **9** is a composite of diagrams showing Western blot analysis of Nef and p24 in Jurkat cells (panel A), HEK293 cells (panel B), THP-1 Monocytes (panel C) and U937 monocytes (panel D).

FIG. **10** is a composite of pictures of Magi/CXCR4 cells transfected with either R7 viral DNA/SMRwt peptide (panel A) or R7 viral DNA/SMRmt peptide (panel B).

FIG. **11** is a composite of diagrams showing Magi assay viral infectivity in Jurkat cells (panel A), HEK293 cells (panel B), THP-1 Monocytes (panel C) and U937 monocytes (panel D).

FIG. **12** is a composite of pictures showing the result of cellular toxicity assay for cells transfected with SMRwt or SMRmt peptide. Panels A-1 and B-1: Propidium iodide staining of cells transfected with SMRwt and SMRmt peptide, respectively. Panels A-2 and B-2: Fluorescein diacetate staining of cells transfected with SMRwt and SMRmt peptide, respectively. Panels A-3 and B-3: Phase microscope image of cells transfected with SMRwt and SMRmt peptide, respectively.

FIG. **13** is a composite of pictures showing immunoprecipitation with SMRwt or SMRmt peptide (panel A) and identification of the 75 kD SMR-specific protein by Western blot.

FIG. **14** is a diagram showing Mortalin antibody inhibition of Nef secretion.

FIG. **15** is a diagram showing a cotransfection assay for monitoring effect of SMR peptide or unknown compound on Nef secretion.

FIG. **16** is a diagram showing a cotransfection assay for monitoring the effect of SMR peptide or unknown compound on tumor vesicle secretion.

DETAILED DESCRIPTION

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

It is known that the cellular trafficking pathway is involved in the lifecycle of HIV and in tumor development (Grossman et al., (2002) Nat. Med. 8, 319-323). For example, the exosomes released by certain tumor cells dysregulate the immune system of the host, thus allowing growth and proliferation of the tumor. Currently, there is no practical technology to target the microparticle trafficking pathway and manipulate/inhibit microparticle release from cells. The present invention takes advantage of a HIV-Nef sequence that interacts with cellular factors and manipulates the trafficking pathway to block the cells ability to make microparticles.

Peptides

One aspect of the present invention relates to a novel peptide that inhibits the release of microparticles from cells. The peptide has a length of 10-100 amino acids and contains (1) at least one VGFPV (SEQ ID NO: 1) motif at the N-terminal, or (2) at least one VGFPV (SEQ ID NO: 1) motif at the C-terminal, or (3) at least two VGFPV (SEQ ID NO: 1) motifs. As used hereinafter, the term "microparticles" refers to microvehicles involved in cellular trafficking pathways. The microparticles are typically composed of a lipid bilayer containing a cytosolic fraction, and are generally less than 200 nm in diameter. Examples of microparticles include, but are not limited to exosomes, texosomes, and Tex or tumor exosomes.

In one embodiment, the peptide contains at least two SEQ ID NO: 1 motifs. In another embodiment, the peptide contains the amino acid sequence VGFPVAAVGFPV (SEQ ID NO: 2). In yet another embodiment, the peptide has the sequence of H2N-VGFPVAAVGFPVDYKDDDDK-OH (SEQ ID NO: 3).

The peptides of the present invention may be chemically synthesized or produced with recombination DNA technology (e.g., expressed and purified from host cells). Methods for synthesizing peptides or producing peptides by recombinant DNA technology are well known to one skilled in the art.

Expression Vectors

Another aspect of the present invention relates to a polynucleotide encoding the novel peptide of the present inven-

tion and an expression vector carrying a polynucleotide encoding the novel peptide of the present invention.

The term "expression vector" refers to a non-viral or a viral vector that comprise a polynucleotide encoding the novel peptide of the present invention in a form suitable for expression of the polynucleotide in a host cell. One type of non-viral vector is a "plasmid," which includes a circular double-stranded DNA loop into which additional DNA segments can be ligated. In the present specification, "plasmid" and "vector" can be used interchangeably as the plasmid is the most commonly used form of vector.

The expression vectors include one or more regulatory sequences, selected on the basis of the host cells to be used for expression, and operably linked to the polynucleotide sequence to be expressed. It will be appreciated by those skilled in the art that the design of the expression vector can depend on such factors as the choice of the host cell to be transformed, the level of expression of protein desired, and the like. The expression vectors of the invention can be introduced into host cells to thereby produce proteins or peptides, such as the novel peptide of the present invention.

As used herein, the term "control sequences" or "regulatory sequences" refers to DNA sequences necessary for the expression of an operably linked coding sequence in a particular host organism. The term "control/regulatory sequence" is intended to include promoters, enhancers and other expression control elements (e.g., polyadenylation signals). Control/regulatory sequences include those which direct constitutive expression of a nucleotide sequence in many types of host cells and those which direct expression of the nucleotide sequence only in certain host cells (e.g., tissue-specific regulatory sequences).

A nucleic acid sequence is "operably linked" to another nucleic acid sequence when the former is placed into a functional relationship with the latter. For example, a DNA for a presequence or secretory leader peptide is operably linked to DNA for a polypeptide if it is expressed as a preprotein that participates in the secretion of the polypeptide; a promoter or enhancer is operably linked to a coding sequence if it affects the transcription of the sequence; or a ribosome binding site is operably linked to a coding sequence if it is positioned so as to facilitate translation. Generally, "operably linked" means that the DNA sequences being linked are contiguous and, in the case of a secretory leader, contiguous and in reading phase. However, enhancers do not have to be contiguous Linking is accomplished by ligation at convenient restriction sites. If such sites do not exist, synthetic oligonucleotide adaptors or linkers are used in accordance with conventional practice.

In one embodiment, the mammalian expression vector is capable of directing expression of the polynucleotide preferentially in a particular cell type (e.g., tissue-specific regulatory elements are used to express the polynucleotide). Tissue-specific regulatory elements are known in the art and may include epithelial cell-specific promoters. Other non-limiting examples of suitable tissue-specific promoters include the liver-specific promoter (e.g., albumin promoter), lymphoid-specific promoters, promoters of T cell receptors and immunoglobulins, neuron-specific promoters (e.g., the neurofilament promoter), pancreas-specific promoters (e.g., insulin promoter), and mammary gland-specific promoters (e.g., milk whey promoter). Developmentally-regulated promoters (e.g., the .alpha.-fetoprotein promoter) are also encompassed.

In another embodiment, the expression vectors are viral vectors. Examples of viral vectors include, but are not limited to, retroviral vectors, lentiviral vectors, adenoviral vectors, adeno-associated viral (AAV) vectors, herpes viral vectors, and alphavirus vectors. The viral vector can also be an astrovirus, coronavirus, orthomyxovirus, papovavirus, paramyxovirus, parvovirus, picornavirus, poxvirus, togavirus viral vector.

The expression vectors of the present invention may express the peptides of the present invention using a regulation expression system. Systems to regulate expression of therapeutic genes have been developed and incorporated into the current viral and nonviral gene delivery vectors. These systems are briefly described below:

Tet-on/off system. The Tet-system is based on two regulatory elements derived from the tetracycline-resistance operon of the *E. coli* Tn10 transposon: the Tet repressor protein (TetR) and the Tet operator DNA sequence (tetO) to which TetR binds. The system consists of two components, a "regulator" and a "reporter" plasmid. The "regulator" plasmid encodes a hybrid protein containing a mutated Tet repressor (rtetR) fused to the VP16 activation domain of herpes simplex virus. The "reporter" plasmid contains a tet-responsive element (TRE), which controls the "reporter" gene of choice. The rtetR-VP16 fusion protein can only bind to the TRE, therefore activates the transcription of the "reporter" gene, in the presence of tetracycline. The system has been incorporated into a number of viral vectors including retrovirus, adenovirus and AAV.

Ecdysone system. The ecdysone system is based on the molting induction system found in Drosophila, but modified for inducible expression in mammalian cells. The system uses an analog of the drosophila steroid hormone ecdysone, muristerone A, to activate expression of the gene of interest via a heterodimeric nuclear receptor. Expression levels have been reported to exceed 200-fold over basal levels with no effect on mammalian cell physiology.

Progesterone system. The progesterone receptor is normally stimulated to bind to a specific DNA sequence and to activate transcription through an interaction with its hormone ligand. Conversely, the progesterone antagonist mifepristone (RU486) is able to block hormone-induced nuclear transport and subsequent DNA binding. A mutant form of the progesterone receptor that can be stimulated to bind through an interaction with RU486 has been generated. To generate a specific, regulatable transcription factor, the RU486-binding domain of the progesterone receptor has been fused to the DNA-binding domain of the yeast transcription factor GAL4 and the transactivation domain of the HSV protein VP16. The chimeric factor is inactive in the absence of RU486. The addition of hormone, however, induces a conformational change in the chimeric protein, and this change allows binding to a GAL4-binding site and the activation of transcription from promoters containing the GALA-binding site.

Rapamycin system. Immunosuppressive agents, such as FK506 and rapamycin, act by binding to specific cellular proteins and facilitating their dimerization. For example, the binding of rapamycin to FK506-binding protein (FKBP) results in its heterodimerization with another rapamycin binding protein FRAP, which can be reversed by removal of the drug. The ability to bring two proteins together by addition of a drug potentiates the regulation of a number of biological processes, including transcription. A chimeric DNA-binding domain has been fused to the FKBP, which enables binding of the fusion protein to a specific DNA-binding sequence. A transcriptional activation domain has also been fused to FRAP. When these two fusion proteins are co-expressed in the same cell, a fully functional transcription factor can be formed by heterodimerization mediated by addition of rapamycin. The dimerized chimeric transcription factor can then bind to a synthetic promoter sequence containing copies

of the synthetic DNA-binding sequence. This system has been successfully integrated into adenoviral and AAV vectors. Long term regulatable gene expression has been achieved in both mice and baboons.

The delivery of the expression vectors of this invention into cells can be achieved by infection (for viral vectors), transfection (for non-viral vectors) and other methods well known to one skilled in the art. Examples of other delivery methods and media include, polycationic condensed DNA linked or unlinked to killed viruses, ligand linked DNA, liposomes, eukaryotic cell delivery vehicles cells, deposition of photopolymerized hydrogel materials, handheld gene transfer particle gun, ionizing radiation, nucleic charge neutralization or fusion with cell membranes. Particle mediated gene transfer may also be employed. Briefly, DNA sequence can be inserted into conventional vectors that contain conventional control sequences for high level expression, and then be incubated with synthetic gene transfer molecules such as polymeric DNA-binding cations like polylysine, protamine, and albumin, linked to cell targeting ligands such as asialoorosomucoid, insulin, galactose, lactose or transferrin. Naked DNA may also be employed. Uptake efficiency of naked DNA may be improved using biodegradable latex beads. The method may be improved further by treatment of the beads to increase hydrophobicity and thereby facilitate disruption of the endosome and release of the DNA into the cytoplasm.

In certain embodiments, the novel peptide of the present invention is introduced in a target cell with one or more other drugs that inhibit secretion. Examples of such drugs include, but are not limited to, dimethyl amiloride, an inhibitor of the H+/Na+ and Na+/Ca2+ channels, and omeprazole, a K+/H+ ATPase inhibitor.

Pharmaceutical Composition

Another aspect of the present invention relates to a pharmaceutical composition for treating AIDS or tumors. The pharmaceutical composition comprises (1) a peptide containing at least one VGFPV (SEQ ID NO: 1) motif at the N-terminal and having a length of 10-100 amino acids or an expression vector encoding such a peptide, and (2) a pharmaceutically acceptable carrier.

In certain embodiments, the pharmaceutical composition further comprises one or more other drugs that inhibit secretion. In one embodiment, the one or more other drugs include dimethyl amiloride or omeprazole or both.

As used herein, the language "pharmaceutically acceptable carrier" is intended to include any and all solvents, solubilizers, fillers, stabilizers, binders, absorbents, bases, buffering agents, lubricants, controlled release vehicles, diluents, emulsifying agents, humectants, lubricants, dispersion media, coatings, antibacterial or antifungal agents, isotonic and absorption delaying agents, and the like, compatible with pharmaceutical administration. The use of such media and agents for pharmaceutically active substances is well-known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the compositions is contemplated. Supplementary agents can also be incorporated into the compositions.

A pharmaceutical composition of the invention is formulated to be compatible with its intended route of administration. Examples of routes of administration include parenteral, e.g., intravenous, intradermal, subcutaneous, oral (e.g., inhalation), transdemial (topical), transmucosal, and rectal administration. Solutions or suspensions used for parenteral, intradermal, or subcutaneous application can include the following components: a sterile diluent such as water for injection, saline solution, fixed oils, polyethylene glycols, glycerine; propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl parabens; antioxidants such as ascorbic acid or sodium bisulfate; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose. pH can be adjusted with acids or bases, such as hydrochloric acid or sodium hydroxide. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

Pharmaceutical compositions suitable for injectable use include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. For intravenous administration, suitable carriers include physiological saline, bacteriostatic water, Cremophor EL™ (BASF, Parsippany, N.J.) or phosphate buffered saline (PBS). In all cases, the injectable composition should be sterile and should be fluid to the extent that easy syringability exists. It must be stable under the conditions of manufacture and storage and must be preserved against the contaminating action of microorganisms such as bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyetheylene glycol, and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the requited particle size in the case of dispersion and by the use of surfactants. Prevention of the action of microorganisms can be achieved by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, ascorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as manitol, sorbitol, or sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions can be prepared by incorporating the active compound (e.g., a fragment of an SRPP or an anti-SRPP antibody) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle which contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and freeze-drying which yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

Oral compositions generally include an inert diluent or an edible carrier. They can be enclosed in gelatin capsules or compressed into tablets. For the purpose of oral therapeutic administration, the active compound can be incorporated with excipients and used in the form of tablets, troches, or capsules. Oral compositions can also be prepared using a fluid carrier for use as a mouthwash, wherein the compound in the fluid carrier is applied orally and swished and expectorated or swallowed. Pharmaceutically compatible binding agents, and/or adjuvant materials can be included as part of the composition. The tablets, pills, capsules, troches and the like can contain any of the following ingredients, or compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose; a disintegrating agent such as alginic acid, Primogel, or corn starch; a lubricant such as magnesium stearate or

Stertes; a glidant such as colloidal silicon dioxide; a sweetening agent such as sucrose or saccharin; or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring.

For administration by inhalation, the compounds are delivered in the form of an aerosol spray from a pressured container or dispenser which contains a suitable propellant, e.g., a gas such as carbon dioxide, or a nebulizer.

Systemic administration can also be by transmucosal or transdermal means. For transmucosal or transdermal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art, and include, for example, for transmucosal administration, detergents, bile salts, and fusidic acid derivatives. Transmucosal administration can be accomplished through the use of nasal sprays or suppositories. For transdermal administration, the bioactive compounds are formulated into ointments, salves, gels, or creams as generally known in the art.

The compounds can also be prepared in the form of suppositories (e.g., with conventional suppository bases such as cocoa butter and other glycerides) or retention enemas for rectal delivery.

In one embodiment, the therapeutic moieties, which may contain a bioactive compound, are prepared with carriers that will protect the compound against rapid elimination from the body, such as a controlled release formulation, including implants and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for preparation of such formulations will be apparent to those skilled in the art. The materials can also be obtained commercially from e.g. Alza Corporation and Nova Pharmaceuticals, Inc. Liposomal suspensions (including liposomes targeted to infected cells with monoclonal antibodies to viral antigens) can also be used as pharmaceutically acceptable carriers. These can be prepared according to methods known to those skilled in the art.

It is especially advantageous to formulate oral or parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form, as used herein, includes physically discrete units suited as unitary dosages for the subject to be treated; each unit contains a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the invention are dictated by and directly dependent on the unique characteristics of the active compound and the particular therapeutic effect to be achieved, and the limitations inherent in the art of compounding such an active compound for the treatment of individuals.

Toxicity and therapeutic efficacy of such compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, e.g., for determining the LD50 (the dose lethal to 50% of the population) and the ED50 (the dose therapeutically effective in 50% of the population). The dose ratio between toxic and therapeutic effects is the therapeutic index and it can be expressed as the ratio LD50/ED50. Compounds which exhibit large therapeutic indices are preferred. While compounds that exhibit toxic side effects may be used, care should be taken to design a delivery system that targets such compounds to the site of affected tissue in order to minimize potential damage to uninfected cells and, thereby, reduce side effects.

The data obtained from the cell culture assays and animal studies can be used in formulating a range of dosage for use in humans The dosage of such compounds lies preferably within a range of circulating concentrations that includes the ED50 with little or no toxicity. The dosage may vary within this range depending upon the dosage form employed and the route of administration utilized. For any compound used in the method of the invention, the therapeutically effective dose can be estimated initially from cell culture assays. A dose may be formulated in animal models to achieve a circulating plasma concentration range that includes the IC50 (i.e., the concentration of the test compound which achieves a half-maximal inhibition of symptoms) as determined in cell culture. Such information can be used to more accurately determine useful doses in humans. Levels in plasma may be measured, for example, by high performance liquid chromatography.

The pharmaceutical compositions can be included in a container, pack, or dispenser together with instructions for administration.

Another aspect of invention includes methods for preparing pharmaceutical compositions for modulating the expression or activity of the peptide of the present invention. Such methods comprise formulating a pharmaceutically acceptable carrier with an agent which modulates expression or activity of the peptide of the present invention. Such compositions can further include additional active agents. Thus, the invention further includes methods for preparing a pharmaceutical composition by formulating a pharmaceutically acceptable carrier with an agent which modulates expression or activity of the peptide of the present invention and one or more additional bioactive agents.

Methods for Treating AIDS and Tumors

Another aspect of the present invention relates to a method for treating AIDS. The method comprises administering to a subject in need of such treatment an effective amount of a peptide containing at least one VGFPV motif and having a length of 10-100 amino acids.

In one embodiment, the peptide contains at least two VGFPV (SEQ ID NO: 1) motifs. In another embodiment, the peptide contains the amino acid sequence VGFPVAAVGFPV (SEQ ID NO: 2). In yet another embodiment, the peptide has the sequence of H2N-VGFPVAAVGFPVDYKDDDDK-OH (SEQ ID NO: 3).

Another aspect of the present invention relates to a method for treating tumors. The method comprises administering to a subject in need of such treatment an effective amount of a peptide containing at least one SEQ ID NO: 1 motif at the N-terminal and having a length of 10-100 amino acids.

In one embodiment, the peptide contains at least two SEQ ID NO: 1 motifs. In another embodiment, the peptide contains the amino acid sequence SEQ ID NO: 2. In yet another embodiment, the peptide further comprises the sequence of H2N-VGFPVAAVGFPVDYKDDDDK-OH (SEQ ID NO: 3).

The present invention is further illustrated by the following examples which should not be construed as limiting. The contents of all references, patents and published patent applications cited throughout this application, as well as the Figures and Tables are incorporated herein by reference.

Example 1

Inhibition of Vesicle Secretion in Tumor Cells

1-1. Cells and Cultures

MDA-MB-231 cells were derived from human breast adenocarcinoma and human breast carcinoma cells, respectively, and were obtained from the American Type Culture Collection (Manassas, Va.). Cells were sustained in RPMI

1640 medium (Invitrogen, Palo Alto, Calif.) supplemented with streptomycin (100 U/ml), penicillin (100 U/ml), L-glutamine (2 mM), and HEPES buffered saline solution (30 μM).

1-2. Antibodies

The following antibodies were used: (i) a mouse monoclonal (MEM-28) anti-CD45 antibody (Abeam, Inc, Cambridge, Mass.); (ii) a murine monoclonal anti-HIV-1 Nef antibody (ImmunoDiagnostic, INC., Ma.); (iii) a monoclonal anti-Acetylcholinesterase (AchE) antibody, clone AE-1 (CHEMICON, Ca.); (iv) an monoclonal anti-Tubulin antibody, clone B-5-1-2 (SIGMA, Mo.) and (v) an goat anti-mouse IgG heavy plus light chains (H+L) labeled with horseradish Peroxidase (Pierce, Rockford, Ill.).

1-3. Exosomes Isolation and Purification from Mda-MB-231 Cells

MDA-MB-231 cells (3×10^5) were transfected with SMRwt (H2N-VGFPVAAVGFPVDYKDDDDK-OH) (SEQ ID NO: 3), SMRmt (H2N-AGFPVAAAGFPVDYKD-DDDK-OH) (SEQ ID NO: 4), pQBI-SMRwt-GFP (FIG. **1**, panel B) or pQBI-SMRmt-GFP (FIG. **1**, panel B) by Chariot™ methods (Active Motif co., Carlsbad, Calif.). The two peptides were made commercially (FIG. **1**, panel A). The SMR sequence is repeated twice at the N-terminal end of the peptide with a short dialanine separating the repeats. Following the SMR sequences is a c-terminal FLAG sequence that allows us to retrieve the peptide. However, any sequence could be inserted at the c-terminus The pQBI-SMRwt-GFP (SEQ ID NO: 5) and pQBI-SMRmt-GFP (SEQ ID NO: 6) constructs were generated by inserting a single copy of the SMR wt sequence or SMR mt sequence, respectively, between the T7 promoter and the GFP coding sequence of the pQBI vector (Qbiogen Inc.)

Briefly, 1 μg of peptides were added into 200 μl serum-free medium with 10 μl Chariot solution, mixed well, and incubated at room temperature for 30 min. The cell cultures plate was washed. 400 μl of Chariot™/DNA/Peptide complex was added into the plate, followed with 1600 μl serum-free medium. The cells were incubated with 5% CO2 at 37° C. for 1 hr, 1 ml of complete growth medium was added into the plate and the plate was incubated at 37° C. with 5% CO2 for 48 hr. The cells were removed from the culture supernatant by centrifugation at 2000×g for 5 min. The supernatant was then subjected to spin at 10,000 g for 30 min to remove cell debris, 1 ml of the 10,000 g supernatant was placed into a centrifuge tube and spun at 50,000×g, 100,000×g and 400,000×g for 2 hr at 4° C. to pellet exosomes. Similarly prepared supernatants from untransfected MDA-MB-231 cells were used as negative controls.

1-4. Immunoblot Analysis

Pellets were resuspended in 1×SDS-PAGE loading buffer, separated by SDS-PAGE. Twenty microliters of each sample was separated by SDS-PAGE on a 4-20% Tris-HCl Criterion precast gel (Bio-Red Laboratories, Hercules, Calif.), and electrophoretically transferred to a nitrocellulose membrane. The membrane was washed in TBS for 5 min, and then blocked with 5% non-fat milk in TTBS (TBS with 0.1% Tween 20) for 1 h by shaking at room temperature and processed for immunoblotting using the primary antibody (anti-acetylcholine esterase (AchE) mAb at 1:1000 dilution) by shaking at 4° C. for overnight, followed by HRP-conjugated IgG Ab (H+L). Protein bands were detected by Western Blotting Luminol Reagent (Santa Cruz Biotechnology, Inc., Santa Cruz, Calif.). After detection of AchE, the blot was stripped and re-hybridized with CD45. Protein bands were detected by Western Blotting Luminol Reagent, followed by exposure to photographic film (BioMax film; Fisher Scientific, Pittsburgh, Pa.). Images were scanned into Adobe Photoshop 6.0, and arranged via Adobe Illustrator software (version 8.0; Adobe Systems) and densitometry was performed using Scion Image J software, Release Beta 3b (Scion Corporation, Frederick, Md.)

As shown in FIG. **1**, antagonist peptide (HIV-1 NefSMRwt; FIG. **1**, panel C) knocked down AChE intracellularly and in the cell supernatant (measure of secretion of tumor vesicles) from MDA-MB-231 cells. The data also displays a dose dependency in both compartments. Negative control (HIV-1 NEfSMRmut, FIG. **1**, panel D) had no effect on AChE in either intracellular or supernatant compartments.

The above results show that the HIV-1 NefSMRwt peptide antagonizes the release of exosomal vesicles from tumor cells. These vesicles have been shown to dysregulate the immune system in cancer patients allowing tumors to survive and thrive. Antagonism of exosome release would allow the immune system to repair itself and attack/kill the tumors.

Example 2

Vesicle Secretion Inhibition 1N HIV-1 NEF Transfected Cells

While the genetic studies clearly showed that mutating the SMR motif abolished Nef secretion, it was not clear whether this effect was due to the disruption of a SMR-binding site, or simply a structural change leading to Nef protein misfolding. Therefore, a set of co-transfection experiments were performed. HEK293 cells were co-transfected with 0.5 μg of pQBI-HIV Nef-GFP (expresses wild type Nef protein) and either 0.5 μg of HIV-1 Nef SMRwt or SMRmut peptide or sM1 peptide (a totally random control peptide, ALAETC-QNAWA (SEQ ID NO: 7)) with Chariot. Briefly, the wild-type Nef-GFP clone and the SMR peptides were complexed with Chariot reagent for 30 minutes at RT. The DNA/peptide/Chariot complex was added to HEK293 cells in serum-free media, and the cells were plated. Following incubation for 2 hours at 37° C., media with serum was added to the dish, and the cells were incubated at 37° C. for 48 h. The media was then collected and assayed for secretion using a spectrofluorimeter. The conditioned supernatants from these cultures were assayed for GFP fluorescence by plate reader. The results are displayed in percent relative to the NefGfP+sM1 peptide (negative control; 100%) fluorescence.

As shown in FIG. **2**, the HIV-1 NefSMRwt peptide (first bar from left) antagonizes the release of NefGFP into the extracellular supernatant. It has been shown that NefGFP is in the exosome like vesicles in the extracellular supernatant. The negative controls HIV-1 NefSMRmut and sM1 had no effect on vesicle release.

These results demonstrate that the antagonist blocks release of HIV-1 Nef transfected cells. The data suggest that these vesicles, similarly to those released the tumor cells, kill or dysregulate the immune system allowing HIV to thrive and eventually lead to AIDS pathogenesis. Antagonism of exosome release would allow the immune system to repair itself blocking progression to AIDS.

In another experiment, Jurkat cells were co-transfected with 500 ng HIV-1wtNef-GFP and 7.8-500 ng of SMRwt peptide by Chariot. As shown in FIG. **3**A the SMRwt peptide inhibits the vesicle secretion in Jurkat cells. FIG. **3**B is a dose-response curve showing that the SMRwt peptide inhibits the vesicle secretion in Jurkat cells in a dose-dependent manner.

Example 3

Inhibition of Vesicle Secretion and Virion Particle Release from HIV Infected Cells

3.1 Experiment I

I. Jurkat cells were co-transfected as shown below: (transfection efficiency 30-40% by Chariot Kit):

#1. pNL4-3 + Nef SMR wt (antagonist)	4 plates
#2. pNL4-3 + Nef SMR mt (nonfunctional antagonist)	4 plates
#3. pNL4-3 + sMl (negative control peptide)	4 plates

pNL4-3 is a clone containing the viral genome. Transfection into cells allows expression of the viral genome and ultimately virion formation and release. The amount of virion production in the extracellular supernatant is measured through p24 protein (viral protein). Samples were collected at 48 hours and 96 hours post-infection.

At 48 hr postinfection two plates in each group were removed and analyzed by:

a. p24 assay

b. Nef assay

c. Infectivity assay

At 96 hr postinfection the other two plates in each group were removed and analyzed by:

a. p24 assay

b. Nef assay

c. Infectivity assay

As shown in Table I, the amount of virus production is reduced drastically at 96 hours in the presence of the peptide antagonist (NefSMRwt) with no effect seen for the negative control peptide (NefSMRmut). The Data suggest that the antagonist blocks production and/or release of virus particles from infected cells.

TABLE 1

Results of Experiment I

Cells	Time	Sample	p24 pg/ml	Effect (a/b)
Jurkat	48 hr	pNL4-3 + NefSMRwt (a)	0	1
		pNL4-3 + NefSMRmut (a)	0	1
		pNL4-3 + sM1 (b)	0	1
Jurkat	96 hr	pNL4-3 + NefSMRwt (a)	0	<0.033
		pNL4-3 + NefSMRmut (a)	15	0.5
		pNL4-3 + sM1 (b)	30	1
293	48 hr	pNL4-3 + NefSMRwt (a)	90	2
		pNL4-3 + NefSMRmut (a)	30	0.67
		pNL4-3 + sM1 (b)	45	1.0
293	96 hr	pNL4-3 + NefSMRwt (a)	345	0.359
		pNL4-3 + NefSMRmut (a)	1125	1.17
		pNL4-3 + sM1 (b)	960	1

3.2 Experiment II

Jurkat cells, HEK293 cells, THP-1 monocytes and U937 monocytes were co-transfected with either R7 or Nef SMR wt (antagonist) or with R7+Nef SMR mt (nonfunctional antagonist) by Chariot™ Kit. The transfection efficiency was 30-40%.

R7 is a clone containing the viral genome. Transfection into cells allows expression of the viral genome and ultimately virion formation and release. The amount of virion production in the extracellular supernatant is measured through p24 protein (viral protein).

At 2 hours, 3 days, 6 days, 9 days, 13 days, 15 days, 17 days, 20 days, 23 days, 27 days and 36 days post-transfection, 0.5 ml supernatant were collected from each plate, mixed with 0.5 ml fresh media and analyzed by p24 ELISA assay. 1.5 ml of supernatant were collected from each plate and spun in a TLA100 rotor at 400,000×g for 1 hour to create the pellets. The pellets were used for Western blot analysis with p24 mAb and Nef mAb.

As shown in FIG. **4**A, the p24 concentrations increased in Jurkat cells 3 days post transfection in the negative control (R7/SMRmt) but did not increase in SMRwt (antagonist) cultures until 13 days post transfection. Similar results were also observed in HEK293 cells and in THP-1 monocytes. There is little p24 in SMRwt transfected U937 monocytes, suggesting that the cells could not eliminate the SMRwt antagonist. These data suggest that SMRwt antagonizes some aspect of viral growth or viral release from infected cells. The effect of SMRwt, however, seems to be temporary. It appears that Jurkat and HEK cells can degrade the peptide over time, while U937 monocytes cannot degrade the peptide. The temporary effect of the peptide may be overcome by using non-degradable peptide (e.g., peptides with sulfur bond, or d-enatomer peptides). FIG. **4**B is a composite of confocal microscopic pictures at day 3, 6, 10, 14, 17 after transfection showing the blockage of p24 release by R7/SMRwt (panel A) but not by R7/SMRmt (panel B) in Jurkat cells. The result matched with data obtained from ELISA/Western/ and MAGI analysis. Blue stain is a nuclear stain, Red stain is cytoplasmic stain, and Green FITC stain is for HIV p24 protein. The p24 can be seen heavily accumulating in the cytoplasm of antagonist treated cells in day 3, 6, 10 images as compared to negative control treated cells in same images. In day 14 and 17, the p24 begins to look like that in the negative control treated images. This matches the fact that the p24 appears to be released in the MAGI/Western/ELISA data as we think the intracellular levels of the peptide are depleted allowing the virus to begin to be released.

FIGS. **4**C-**4**E are electron microscopic pictures showing Jurkat cells transfected with R7/SMRwt or R7/SMRwt at day 6 (FIG. **4**C) and day 14 (FIG. **4**D) post transfection. On day 6, viral particles or nucleocapsid can be observed accumulating in to cytoplasm and within the MVBs inside the cells treated with R7/SMRwt. No viral particles can be observed accumulating on the extracellular surface of these cells (FIG. **4**C, panel A-1 and). In contrast, very few MVBs can be observed inside the cell treated with R7/SMRmt, with most of the viral particles observed accumulating on the extracellular surface of the cell and polarized on the southern pole of the cell (FIG. **4**C, panels B-1). On day 14, viral particles can be observed accumulating on the extracellular surface of the cell treated with R7/SMRwt (FIG. **4**D, panel A-2) nonpolarized across the entire membrane surface, very much as observed in cells treated with R7/SMRmt, the negative control (FIG. **4**D, panel B-2). Higher magnification images are shown in the following pictures of both six and 14 day antagonist and negative control peptide images to show the electron dense 'viral particles' accumulating as described above (FIG. **4**E). The evidence shows that the SMRwt antagonist delays release of virus from infected cells as measured by EM.

The results of the Western blot analysis are shown in FIGS. **5**-**8**. The results are summarized in FIG. **9**. As shown in FIGS. **3**-**9**, the amount of virus production in the presence of the peptide antagonist (NeISMRwt) is drastically reduced to zero or close to zero. No effect is observed for the negative control peptide (NefSMRmut). Assays of the cell lysates show that the production of p24 is the same in all assay conditions suggesting no effect on viral protein expression. The data suggest that the antagonist blocks release of virus particles from infected cells. This is possibly due to antagonism of

trafficking of viral component(s) to the cytoplasmic membrane. Ultimately this would (i) shutdown the HIV infection and (ii) block progression to AIDS.

3.3 Experiment III

Magi/CXCR4 cells were exposed to 48 hour conditioned supernatants from Jurkat cells, HEK293 cells, THP-1 monocytes, or U937 monocytes transfected with either R7 viral DNA/SMRwt peptide or R7 viral DNA/SMRmt peptide. These cells were then fixed and stained with X-Gal. FIG. **10**A shows Magi/CXCR4 cells exposed to a 1 ng/ml dilution of p24 supernatant from Jurkat cells transfected with R7/SMRwt. FIG. **10**B shows Magi/CXCR4 cells exposed to a 1 ng/ml dilution of p24 supernatant from Jurkat cells transfected with R7/SMRmt. Cells productively infected with R7 are easily visualized under light microscopy by their blue nuclear staining. Magnification ×20. Note the cells treated with R7 and the peptide antagonist (SMRwt) display drastically reduced numbers of blue staining cells, while the cells treated with R7 and the negative control peptide (SMRmt) display many blue staining cells. This is indicative of virus in the conditioned supernatant from the R7/negative control peptide treated cells and no virus in conditioned supernatant from the R7/antagonist treated cells.

These Magi cultures were quantitated for blue staining cells. The data was plotted as a function of time post-transfection. As shown in FIG. **11**, the numbers of infected cells in the presence of the supernatant from NefSMRwt transfected Jurkat cells or NefSMRwt transfected THP-1 monocytes are significantly reduced. The data suggest that the antagonist blocks release of virus particles from infected cells. This is possibly due to antagonism of trafficking of viral component(s) to the cytoplasmic membrane. Ultimately this would shutdown the HIV infection and block progression to AIDS.

In summary, these experiments demonstrate that this technology could be used to force cells to make and extracellularly secrete any protein or epitope, so that the protein or epitope can be easily purified from the cells. The vesicles could also be used for chemotherapy if loaded with a targeting epitope (e.g., antibody epitope to a tumor marker) and an antitumor protein or epitope. Further, with this technology the vector could be transfected into the specific patient cells so as to be using self-vesicles.

Because the protein is also located on the outer membrane of the vesicles, they could also be used to induce an immune response. Thus, for example, flu epitopes may be loaded into the vector and expressed on the outside of the vesicles to induce immune response to flu virus.

Example 4

Effect of the Secretion Antagonist (HIV NEF SMRWT Peptide) on HIV-1 GAGWT-GFP-Induced Secretion

Cells were co-transfected with 0.5 μg of pQBI-HIV Gag-GFP (expresses wild type Gag protein) and either 0.5 μg of HIV-1 Nef SMRwt, SMRmut peptide, sM1 peptide or untransfected controls with Chariot for 48 hours. The conditioned supernatants from these cultures were assayed for GFP fluorescence by plate reader. The results are shown in Table II. Particle secretion levels are displayed relative to the untransfected control which is arbitrarily set as 1× (negative control; 100%).

TABLE II

Increase in Secretion (relative to untransfected cells) Fluorescent Plate Reader Assay

Cell Lines	HIV-1 Gag-GFP/SMRwt	HIV-1 Gag-GFP/SMRmt	GFP/sM1	Untransfected
Jurkat	47.46x 1y	58.22x 1.22y	1.09x	1x
HEK293	24.22x 1y	25.96x 1.08y	2.05x	1x
THP-1	41.3x 1y	45.06x 1.08y	0.85x	1x
U937	43.95x 1y	43.82x 1y	1.05x	1x
Cell Lines	HIV-1 Nef-GFP/SMRwt	HIV-1 Nef-GFP/SMRmt	GFP/sM1	Untransfected
H	2.3x 1.0y	57.04x 24.8y	1.05x	1x

x—exp condition/UT;
y—SMRmt/SMRwt

Gag has been shown to be secreted from Gag-transfected cells in what are called 'virus-like particles'. These virus-like particles are very much like vesicles. It has been suggested that the virus (which has been described as a Gag type vesicle) is released from cells via the exosome pathway. The secretion antagonist SMRwt had no effect on Gag virus-like particle release. This suggests that the Gag trafficking pathway and the Nef trafficking pathway differ at least one point. This point is that factor(s) in the pathway that the antagonist manipulates.

Example 5

Effect of the Secretion Antagonist (HIV NEF SMRWT Peptide) ON HIV-1 GAGWT-GFP-Induced Secretion in Presence of WTNEF Protein

Cells were transfected with the pQBI-HIV Gag-GFP construct, wtNef-RFP, and either the antagonist (SMRwt peptide), the negative control SMRmt peptide, or a random peptide sM1 with Chariot for 48 hours. The conditioned supernatants from these cultures were assayed for GFP fluorescence by plate reader. The results are shown in Table III. Particle secretion levels are displayed relative to the untransfected control which is arbitrarily set as 1× (negative control; 100%).

TABLE III

Inhibition of Secretion (relative to untransfected cells) Fluorescent Plate Reader Assay

Cell Lines	Gag-GFP + HIV-1wtNef-RFP + SMRwt	Gag-GFP + HIV-1wtNef-RFP + SMRmt	Gag-GFP + HIV-1wtNef-RFP + sM1	Untransfected
Jurkat	1.3x 1.16x	55.73x 43.51x	61.99x 40.36x	1x 1x
THP-1 Monocyte	0.95x 0.91x	49.27x 22.24x	43.11x 20.51x	1x 1x

As shown in Table III, in the presence of wtNef-RFP the SMRwt antagonist peptide blocks release of Gag virus-like particles. These results show that the SMRwt does not antagonize Gag VLP formation and release when Gag is in the cell alone, but SMRwt does antagonize Gag VLP formation and release when Gag and Nef are both in a cell. It suggests that Nef is directing Gag release into a pathway different from the

pathway Gag takes when it is in a cell by itself. It also explains why the SMRwt peptide can block HIV virus release but not Gag virus-like particle release (when only Gag is present).

As shown in Table III, In the presence of wtNef-RFP the SMRwt antagonist peptide does block the release of Gag virus-like particles in the presence of wtNef-RFP.

Example 6

Cellular Toxicity Assay for SMRWT Peptide

SMRwt or SMRmut (negative control) peptide alone were transfected into Jurkat cells using Chariot. The transfected cells were allowed to grow for 48 hours. The cells were assayed by Fluorescein diacetate (FD; taken up by live cells and converted to FITC making cells fluoresce green) and propidium iodide (PI; diffuse across porous membranes of dying cells fluoresing red inside those cells) for cytotoxicity.

As shown in FIG. **12**, only a very small number of dying cells (<2%) were detected in SMRwt transfected cells (panel A-1). Further, the number of dying cells in SMRwt transfected cells is similar to that seen in SMRmut transfected cells (Panel B-1). These results suggest that the SMRwt antagonist has very little or no cytotoxicity in Jurkat cells.

Example 7

Identifying Cellular Factors that Interact with the Antagonist

A: Identification of Cellular Factors that Bind the SMRwt Peptide and Regulate Secretion.

SMRwt vs. SMRmt peptides were used in conjunction with FLAG immuno-precipitation on Jurkat cell lysates to pulldown cellular factors that interacted with the SMRwt antagonist, but not with the SMRmt negative control. The cellular factor(s) that interact with the antagonist are analyzed by the FLAG IP assay. Briefly, cell lysates are combined with AminoLink Plus resin coupled to FLAG-tagged SMR peptides. SMR-specific cellular proteins (ROY) bind to the SMR peptides on the resin. Non-specific contaminants (G BIV) are washed off of the resin and removed by centrifugation. The SMR-specific cell proteins (ROY) are eluted and collected. Some strongly bound contaminants (V) are also eluted and collected.

The pulldown products were separated on SDS PAGE ((FIG. **13**, panel A). Bands that appeared in the SMRwt lane but not in the SMRmt lane were cut out and purified. Five bands were identified and purified in this manner (FIG. **13**, panel A). MALDI TOF MS/MS and LC/MS/MS were used to identify these protein products and were found to be Mortalin/GRP75; Myosin 10; Vimentin; GRP78; HSC70. Among these proteins, mortalin/GRP75 is a member of the Hsp70 family of chaperones. It is located in both mitochondria and cytoplasm, and has been implicated in multiple functions ranging from stress response, intracellular trafficking, antigen processing, and control of cell proliferation, differentiation, and tumorigenesis. Mortalin interacts with p53, and is shown to be involved in apoptosis and vesicle transport (MAC complex). It is also found in microvesicles released by tumor cells.

The gel was also Western probed with α-Mortalin antibody. A protein with a molecular weight of ~75 kDa was detected in the lanes containing the cell lysate, the antagonist eluate, and the antagonist affinity resin (FIG. **13**, panel B, Lanes 1, 3, and 5), but not in the negative control or negative control peptide eluate's lanes (FIG. **13**, panel B, Lanes 2 and 4).

Mortalin Antibody Inhibition of Vesicle Secretion

Chariot transfection of a Mortalin/GRP75 antibody into Jurkat cells with the wtNefGFP control was used to knockdown the endogenous Mortalin/GRP75 protein to observe the effect on Nef-induced secretion (FIG. **14**). A-tubulin antibody was chariot transfected into matched cells as a negative control. We observed that the Mortalin/GFP75 antibody blocked NEf-induced secretion while the a-tubulin antibody had no effect on Nef-induced secretion. This showed that Mortalin is important in Nef-induced exosome secretion. Mortalin antibody hybridizes to eluate band.

Mortalin is also known as glucose-regulated protein 75 (GRP75), or peptide-binding protein 74 (PBP74). Mortalin is a 679 amino acid long, uninducible member of the heat shock protein 70 families. It has a high degree of identity with other family members including Escherichia coli DnaK. Although the crystal structure of Mortalin has not been deduced, based on the evolutionary conservation within the Hsp70 family, it is expected to have two principal domains, the N-terminal ATPase nucleotide binding domain (NBD) and C-terminal substrate binding domain (SBD), joined by a protease-sensitive site. The NBD is highly conserved across the family, while the SBD displays significant diversity possibly explaining the variation among Hsp70 family members in substrate specificity. Its chaperone activities are intimately linked with the ATP-hydrolysis function.

Mortalin has been found to be localized to the mitochondria as well as to various cytoplasmic vesicles, including early endocytic vesicles (See, e.g., Kanai et al., Genes Cells, 2007, 12:797-810; Kaul et al., Exp. Gerontol., 2002, 37:1157-1164; Singh et al., Exp Cell Res, 1997, 234:205-216 and Van Buskirk et al., J. Immunol. 1991, 146:500-506). Mortalin binds directly to several proteins (e.g., p53 and FGF-1) and regulates their intracellular trafficking (see, e.g., Kaul et al., J Biol Chem, 2005, 280:39373-39379; Mizukoshi et al., Biochem Biophys Res Commun, 2001, 280:1203-1209; Mizukoshi et al., Biochem J, 1999, 343:461-466; and Prudovsky et al., J Cell Biochem, 2008, 103:1327-1343) through the non-classical pathway (i.e., exosomal pathway). Cells under attack by the host immune system release membrane vesicles through Mortalin expression, and Mortalin is found in those vesicles (Pilzer et al., Int Immunol, 2005, 17:1239-1248). Mortalin is also found in the exosomes released by various tumor cells (Choi et al., J Proteome Res, 2007, 6:4646-4655; Staubach et al., Proteomics, 2009).

Mortalin has been found to play multiple major functions in the cell (reviewed in Kaul et al., Exp Ger ontol, 2007, 42:263-274). It serves a major housekeeping function in the cellular translocation system of import and export of proteins. Although not induced by heat, mild stress responses induce Mortalin allowing it to serve as a guardian against stress and apoptosis. Decreased expression of Mortalin, or expression of mutant forms of Mortalin, lead to senescence, while increased expression of Mortalin leads to immortality, with the aberrant form being cancer.

Evidence clearly implicates Mortalin in transformation of normal cells to cancer cells, as well as in the chemotherapy resistance of those cells. Mortalin was found to be overexpressed in tumor cells of various origins (Wadhwa et al., Int J Cancer, 2006, 118:2973-2980). The murine Mortalin was found to change its subcellular location from mitochondria, in normal cells, to the cytosol in cancerous cells (Wadhwa et al., J Biol Chen 1998, 273:29586-29591). Mortalin was found to interact with p53. Further, this interaction promotes seques-

tration of p53 in the cytoplasm, thereby inhibiting its nuclear activity (Kaul et al., Supra 2007, 42:263-274; Yi et al., Mol Cell Proteomics, 2008, 7:315-325; Czamecka et al., Cancer Biol Ther, 2006, 5:714-720), inducing the resistance of some tumors to radiotherapy and chemotherapy. Finally, as discussed above, Mortalin has been linked with intracellular trafficking leading to exosome release and has been shown to be in exosomal vesicles (Pilzer et al. pringer Semin Immunopathol, 2005, 27:375-387; Choi et al., J Proteome Res, 2007, 6:4646-4655; Staubach et al., Proteomics, 2009). Tumor cells (e.g., breast tumors) have been found to secrete, in a regulated manner, exosomes that carry tumor antigens, and are capable of presenting these antigens or transmitting them to antigen presenting cells (Yu et al., J Immunol, 2007, 178:6867-6875). These tumor exosomes cause immune suppression through immune cell killing or dysregulation, thereby promoting a state of immune privilege that allows for tumor growth. Thus, through a variety of mechanisms, the tumor manipulates Mortalin enhancing its own fitness.

Heat shock 70 family proteins have been found to be linked with breast cancer. They have clear associations with poor differentiation, lymph node metastasis, increased cell proliferation, block of apoptosis, and higher clinical stage in breast cancer. All these morphologies are markers of poor clinical outcome (Calderwood et al., Int J Hyperthermia, 2008, 24:31-39; Calderwood et al., Trends Biochem Sci, 2006, 31:164-172; Ciocca et al., Cell Stress Chaperones, 2005, 10:86-103). Additionally, it has been clearly shown that over-expression of Mortalin contributes to carcinogenesis in many cell types, specifically having been observed in breast cancer cells (Wadhwa et al., Int J Cancer, 2006, 118:2973-2980).

It is clear from the literature that Mortalin is a potential target for cancer immunotherapy, and there are a number of studies looking to develop therapeutics (Wadhwa et al., Cancer Therapy, 2010, 1:173-178; Walker et al., Am J Pathol, 2006, 168:1526-1530; Deocaris et al., Cancer Lett, 2007, 252:259-269; Pilzer et al., Int J Cancer, 2009; Parolini et al., J Biol Chem, 2009). For example, MKT-077 is a mitochondrion-seeking delocalized cationic dye that causes selective death of cancer cells (Deocaris et al., Cancer Lett, 2007, 252:259-269). Its cellular targets include oncogenic Ras, F-actin, telomerase, and Mortalin (hmot-2)/mthsp70 (Parolini et al., J Biol Chem, 2009). MKT-077 binds to the nucleotide-binding domain (NBD) of Mortalin and causes tertiary structural changes in the protein, inactivating its chaperone function, and inducing senescence in human tumor cell lines. In clinical trials, this molecule was found to cause renal toxicity, although there is some evidence now suggesting lower doses could be less toxic.

Example 8

Other Drugs that Inhibit Vesicle/Virus Release

The HIV Nef SMRwt peptide may be used in conjunction with drugs that have been approved by the FDA for use in other conditions and have been identified as having efficacy in blocking virus release as well as vesicle release. Examples of such drags are: dimethyl amiloride and omeprazole.

A cotransfection assay has been developed that can be used to screen for agents that block secretion. In procedure one (FIG. **15**), NefGFP, NefRFP, or Nef linked to any fluorescent tag, is transfected into a cell line and the cell is treated with an agent or chemical during a 48 hr incubation period. Then, at 48 hr post transfection, the conditioned supernatant is assayed for the fluorescent molecule (by various techniques). In procedure two (FIG. **16**), the cell is treated with a fluorescent label like N—Rh-PE that will label endogenously made exosomes. The cell is allowed to incubate for at least 24 hours in the presence or absence of a chemical or small peptide antagonist. The conditioned supernatant is then assayed for N—Rh-PE labeled microvesicles/exosomes (by various techniques). The lack of the fluorescent tag in the conditioned supernatant is a sign that the chemical agent has blocked the exosome secretion pathway blocking Nef induction of that pathway. This procedure should be able to be modified to develop a high throughput assay for screening of agents that block secretion.

The above description is for the purpose of teaching the person of ordinary skill in the art how to practice the present invention, and it is not intended to detail all those obvious modifications and variations of it which will become apparent to the skilled worker upon reading the description. It is intended, however, that all such obvious modifications and variations be included within the scope of the present embodiment, which is defined by the following claims. The claims are intended to cover the claimed components and steps in any sequence which is effective to meet the objectives there intended, unless the context specifically indicates the contrary.

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What is claimed is:

1. A method for reducing the formation of virion particles in an HIV-infected cell, comprising:

contacting an HIV-infected cell in a human subject with a peptide containing at least two SEQ ID NO: 1 motifs and having a length of 10-100 amino acids in an amount effective to reduce virion formation in said cell.

2. The method of claim **1**, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the N-terminal end of the peptide.

3. The method of claim **1**, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the C-terminal end of the peptide.

4. The method of claim **1**, wherein said peptide comprises the amino acid sequence of SEQ ID NO: 2.

5. The method of claim **1**, wherein said peptide comprises the amino acid sequence of SEQ ID NO: 3.

6. A method for reducing the formation of virion particles in an HIV-infected cell, comprising:

contacting an HIV-infected cell in a human subject with a polynucleotide encoding a peptide containing at least two SEQ ID NO: 1 motifs and having a length of 10-100 amino acids in an amount effective to reduce virion formation in said cell, wherein said polynucleotide is capable of expressing said peptide in said cell.

7. The method of claim **6**, wherein said peptide comprises the amino acid sequence SEQ ID NO: 2.

8. The method of claim **6**, wherein said peptide comprises the amino acid sequence of SEQ ID NO: 3.

9. The method of claim **6**, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the N-terminal end of the peptide.

10. The method of claim **6**, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the C-terminal end of the peptide.

11. A method for reducing the formation of virion particles in an HIV-infected cell, comprising:

contacting an HIV-infected cell in a human subject with an expression vector comprising a polynucleotide encoding a peptide containing at least two SEQ ID NO: 1 motifs and having a length of 10-100 amino acids in an amount effective to reduce virion formation in said cell, wherein said expression vector is capable of expressing said peptide in said cell.

12. The method of claim **11**, wherein said peptide comprises the amino acid sequence SEQ ID NO: 2.

13. The method of claim 11, wherein said peptide comprises the amino acid sequence of SEQ ID NO: 3.

14. The method of claim 11, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the N-terminal end of the peptide.

15. The method of claim 11, wherein said peptide comprises at least one SEQ ID NO: 1 motif at the C-terminal end of the peptide.

16. The method of claim 11, wherein said expression vector is a viral vector.

17. The method of claim 11, wherein said expression vector is a non-viral vector.

* * * * *